Technical Drainage Study

For

East Loop Road Section 3,
Golden Valley Ranch
Mohave County, AZ

June 2006
SCI Project # 18449.03.02

Prepared for:

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2215 Hualapai Mountain Road, Suite H
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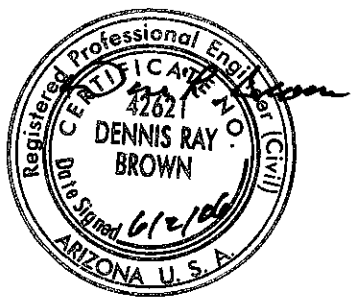

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- HEC-HMS 10-yr, 6-hr Simulation
- NOAA Atlas 14 – Precipitation
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- East Loop Road Sta. 175+00
- East Loop Road Sta. 191+00

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(See Grading Plans this Project)

1. GENERAL LOCATION AND DEVELOPMENT DESCRIPTION

1.1. Introduction

This study is submitted as the technical drainage study for the proposed improvement plans for Section 3 of the East Loop Road and comprises approximately 1600 feet of the East Loop Road. Section 3 is a portion of the overall roadway system within the master planned community of Golden Valley Ranch.

Golden Valley Ranch is located in the Sacramento Valley of Mohave County, Arizona, more specifically on the south side of the Golden Valley Community, near Kingman.

The purpose of this study is to calculate and evaluate the storm runoff within Section 3 of the East Loop Road.

1.2. Location

The Golden Valley Ranch project site consists of Taxpin Numbers 215-01-048, 215-01-075, 215-01-078, 215-01-079, 215-01-080, 215-01-084, 215-01-085, 215-01-092, & 215-15-005 within Township 20 North, Range 18 West and Township 21 North, and Range 18 West, G&SRM, Mohave County, Arizona (Figure 1 - Vicinity Map and Regional Drainage Scheme). East Loop Road Section 3 of the East Loop Road is located in a portion of the south half of the northeast quarter of Section 3, Range 18 West, Township 20 North, G&SRM, Mohave County, Arizona.

1.3. FEMA Flood Hazard Zone

Figure 2 is a representation of the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) for Mohave County, AZ, map number 040058 2325C, dated October 20, 2000. All of Section 3 lies within Zone C. Zone C is the flood insurance rate zone that is above the level of the 500-year flood.

2. SITE DESCRIPTION

2.1. Description of Property

The project lies on a westerly sloping alluvial fan originating from the Cerbat Mountains to the east and is located between the Thirteen Mile Wash and the Holy Moses Wash. This area is semiarid desert rangeland with covering of desert shrub in poor condition. Section 3 of the East Loop Road is located along the northern edge of the Area 3 residential development.

Figure 1 – Vicinity Map and Regional Drainage Scheme

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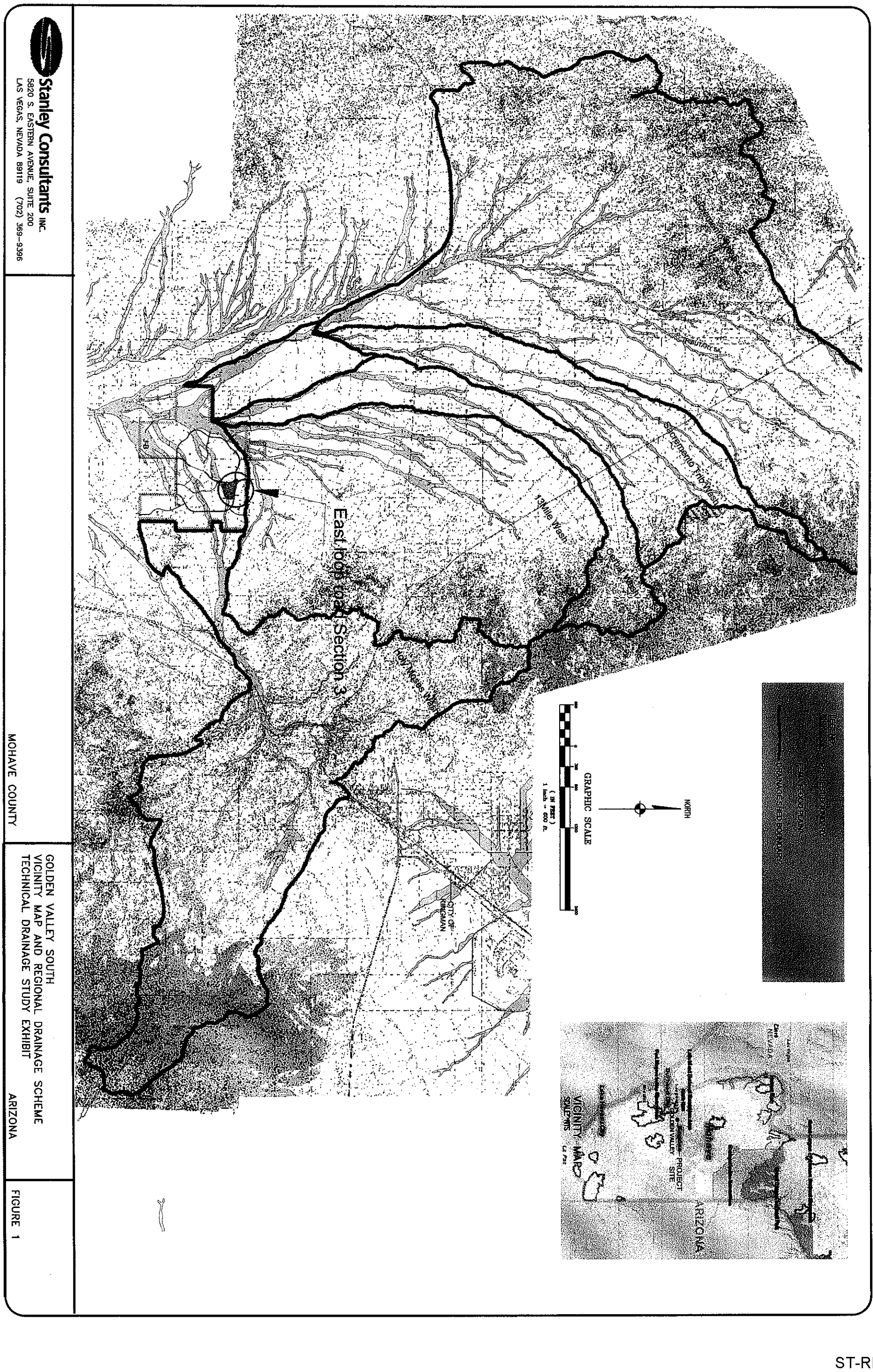

Figure 2 - Flood Insurance Rate Map, Mohave County, Arizona

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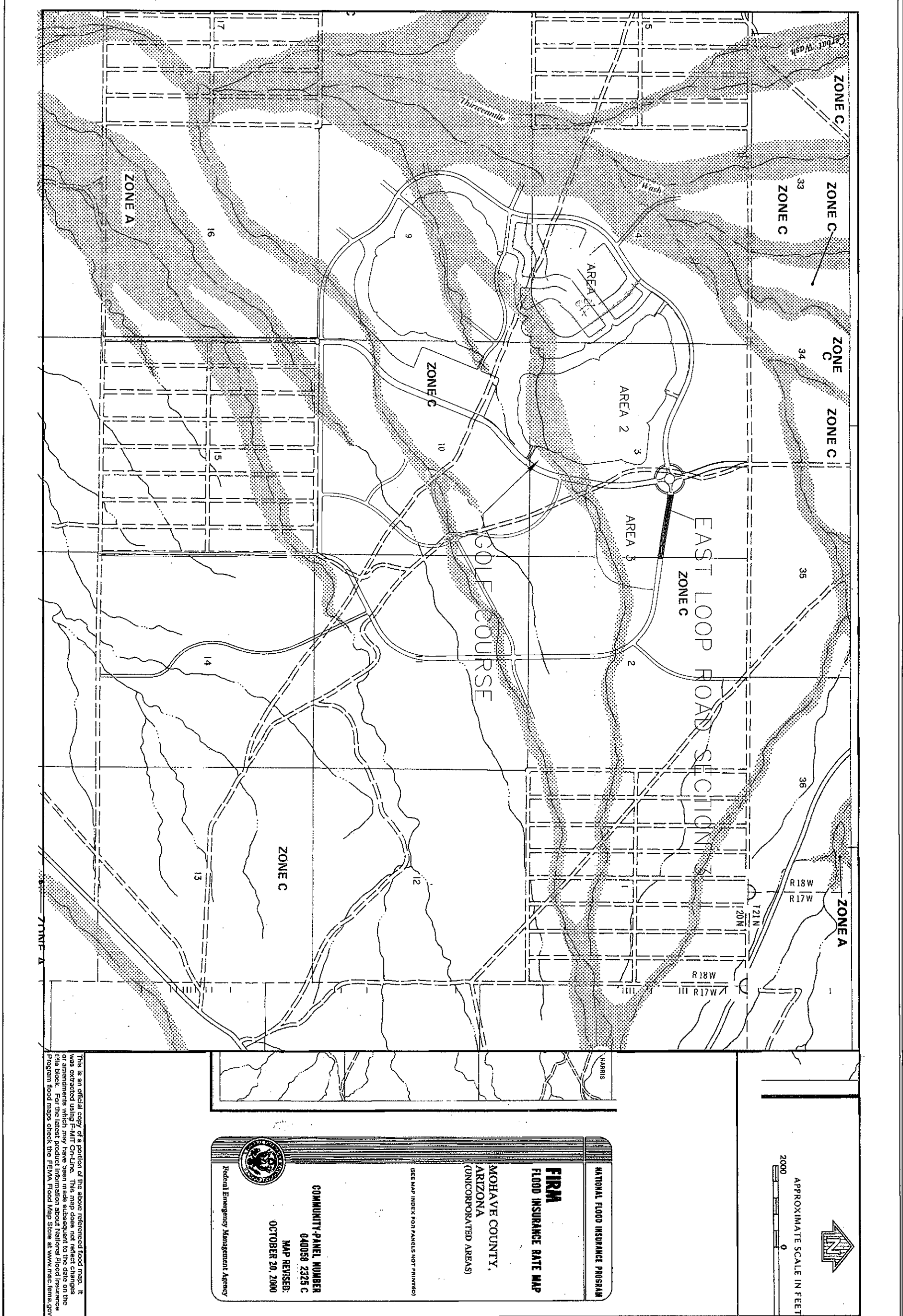

FIGURE 2

The project involves the construction of the East Loop Road from station 175+00.00 to station 191+00 which includes a 25' median and two 25' paved drivable surfaces with curb and gutter located within an 80' right-of-way. A sidewalk and a drainage swale will be constructed within each 25' public utility easement located adjacent to the 80' right-of-way. Two entry ways will also be constructed to allow access to Area 3. The drainage swale within the south utility easement will begin on the west side of the west entry. The drainage swale within the north utility easement will begin offsite at station 148+15.48 of the future East Loop Road. Both swales will be constructed up to the projects west limit at station 191+00.

2.2. Pre-developed Drainage Condition

The pre-developed drainage condition analyzes the impact of drainage with the developed Section 3 and Area 3 to the south. Other existing offsite areas contributing flow to the site are undeveloped.

The drainage swale located within the utility easement on the north side of the 80' right-of-way will begin where the south boundary of sub-shed OS-3 intersects the future alignment of East Loop Road. At this location a highpoint in the future East Loop Road alignment will prevent flows from sub-shed OS-6 and the Holy Moses Wash Diversion Wash 1 from reaching the swale. The future East Loop Road south of this high point will convey these flows back to the Holy Moses Wash main channel as stated in the Master Drainage Plan for Golden Valley Ranch. The swale will intercept pre-developed flows from sub-shed OS-3 and convey them along the north side of the future alignment of the East Loop Road to the beginning of Section 3. These flows will then combine with flows from OS-4 as they are conveyed westerly to junction point J-S3A. Other offsite flows impacting Section 3 are generated by developed sub-shed P3-45 of Area 3. This sub-shed accounts for the runoff entering Section 3 generated by the entrance to Area 3. No other flows generated by Area 3 enter Section 3. The offsite flows entering the site will combine with flows from onsite sub-shed S3-1 at junction point J-S3A.

Rainfall runoff generated within the roadway portion of sub-shed S3-1 travels westerly along the curb and gutter from the beginning to the end of the project near Aztec Road. Scuppers in the curb will prevent the flow from exceeding the road capacity and will satisfy dry lane criteria for the 10-yr storm event. Flows extracted from the road at the scuppers will enter the drainage swales located in the adjacent utility easements where they are combined with offsite flows and flows generated within the easements. The flows at junction point J-S3A will discharge from the site at station 191+00. As the flows proceed west they will be intercepted by a group of drop inlets located at a low point on East Loop Road just east of Aztec Road. Additional flows from Aztec Road will also be received by the drop inlets. Flows received by the north drop inlet will be conveyed north along the east side of the Aztec Road Alignment to a dual culvert. The dual culvert will deliver the flows under Aztec Road to an open channel. This channel will convey these flows west to The Thirteen Mile Wash. Flows received by the south drop inlet will conveyed southerly to the Common Easement D Shed P3-44 storm drain proposed with the Area 3 drainage study and will combine with flows within the Area 3 Storm. The combined flows will then be discharged west of Aztec Road into the golf course adjacent to Area 2 (See Figure 3, *Section 3 Drainage Shed Map*).

2.3. Future Drainage Condition

The future drainage condition analyzes the impact of drainage with the future East Loop Road being developed. All other characteristics with this condition are identical to the pre-developed condition.

Flows generated within the future road way (sub-shed S3-2) will be conveyed within the roadway until they reach Section 3. These flows will begin at the future highpoint located at the beginning of the drainage swale that will be constructed with this project. Flows from sub-shed OS-3 will be received by the drainage swale and will be contained within the swale. The flows received by Section 3 from the development of the future East Loop Road will add to the flows in the pre-developed condition and will discharge at the west end of the Section 3. The future flows within and downstream of Section 3 will maintain the flow patterns discussed in the pre-developed condition.

It is assumed that future developed runoff from offsite sources will be released into the East Loop Road drainage system at pre-developed rates.

3. METHODS AND CRITERIA

3.1. Methodology

The HEC-HMS model was used for the simulation of flood events in watersheds and river sub-sheds using SCS methods. This computer model simulates the surface runoff response of a drainage water-shed to precipitation by representing the sub-shed as an interconnected system of hydrologic and hydraulic components. Each component models an aspect of the rainfall-runoff process within a portion of the whole water-shed. This water-shed portion is referred to as a sub-shed. The runoff hydrographs of each sub-shed are then combined and a final discharge hydrograph is obtained. HEC-HMS was chosen as the hydrology model since it is the model used in a Preliminary Federal Insurance Study prepared for Mohave County Flood Control District, October 2005 for various watersheds in the Golden Valley and Kingman, AZ area. This adds consistency and reliability in the methodology. Curve numbers were calculated for existing conditions outside the roadways only as the developed property will have to detain flow back to existing conditions. Roadway sub-sheds were calculated as a composite of asphalt and landscaping areas.

Calculations for street and swale capacity are produced using FlowMaster by Haestad Methods, Inc.

3.2. Drainage Shed and Modeling Convention

The basic naming convention of the sub-sheds for the exhibits and model are based around the individual drainage shed of the development. Sheds are labeled as P3-44, identifying Area 3, Shed 44. Junction points or points of runoff confluence are identified as J-S5, identifying that it

is a junction point and a label. An R designates a routing of a shed or junction, therefore R-JS5 represents routing of junction J-S5 to another point.

Q:\18449\Drainage\East Loop Rd\Exhibits_KN\Figure 3 - Section 3 Drainage Basins.dwg, 6/1/2006 3:52:44 PM, \\wg-ps1\hp5500-tr-pcl, 1:1.79616
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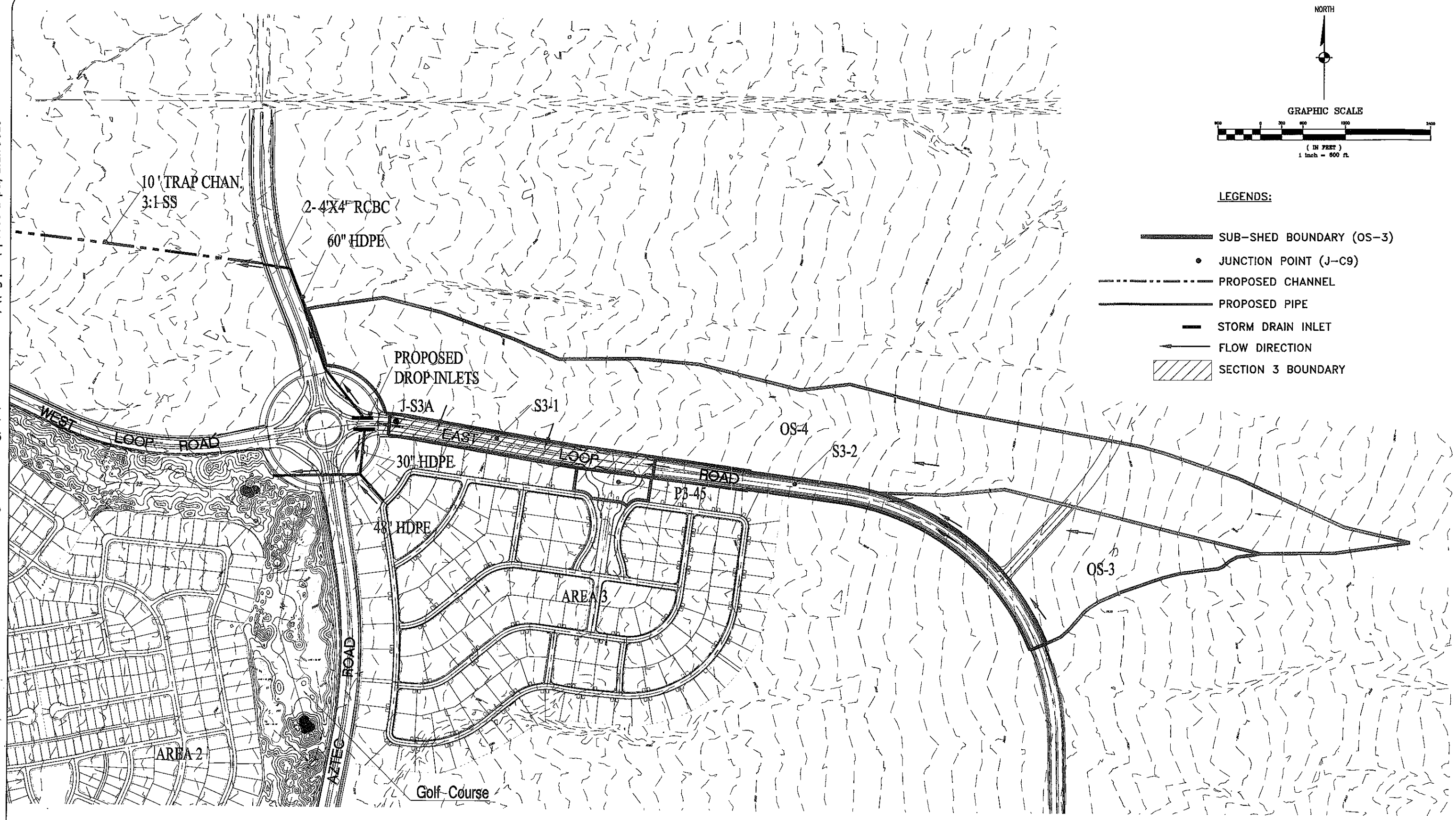

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GOLDEN VALLEY RANCH
SECTION 3 DRAINAGE SUB-SHEDS
TECHNICAL DRAINAGE STUDY EXHIBIT

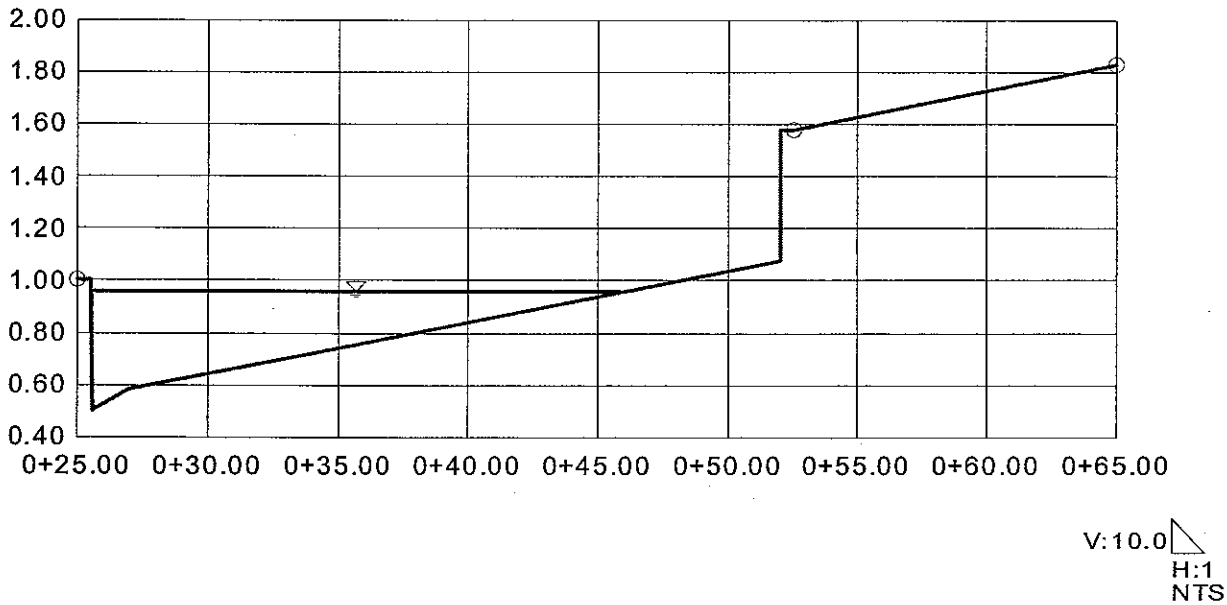
MOHAVE COUNTY ARIZONA FIGURE 3

East Loop Road Sta. 175+00 - South Half - Roadway - Q100 = 15cfs

Cross Section for Irregular Channel

Project Description	
Worksheet	East Loop Road - South Half - Road
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficie	0.016	
Channel Slope	0.013000	ft/ft
Water Surface Elev	0.96	ft
Elevation Range	.50 to 1.83	
Discharge	15.00	cfs



East Loop Road Sta. 175+00 - South Half - Roadway - Q100 = 15cfs

Worksheet for Irregular Channel

Project Description	
Worksheet	East Loop Road - South Half - Road
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Channel Sl	013000	ft/ft
Discharge	15.00	cfs

Options	
Current Roughness Meth	ved Lotter's Method
Open Channel Weighting	ved Lotter's Method
Closed Channel Weightin	Horton's Method

Results		
Mannings Coefficie	0.016	
Water Surface Elev	0.96	ft
Elevation Range	).50 to 1.83	
Flow Area	4.1	ft²
Wetted Perimeter	20.68	ft
Top Width	20.29	ft
Actual Depth	0.46	ft
Critical Elevation	1.02	ft
Critical Slope	0.006237	ft/ft
Velocity	3.62	ft/s
Velocity Head	0.20	ft
Specific Energy	1.16	ft
Froude Number	1.41	
Flow Type	Supercritical	

Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+25.00	0+52.50	0.016
0+52.50	0+65.00	0.035

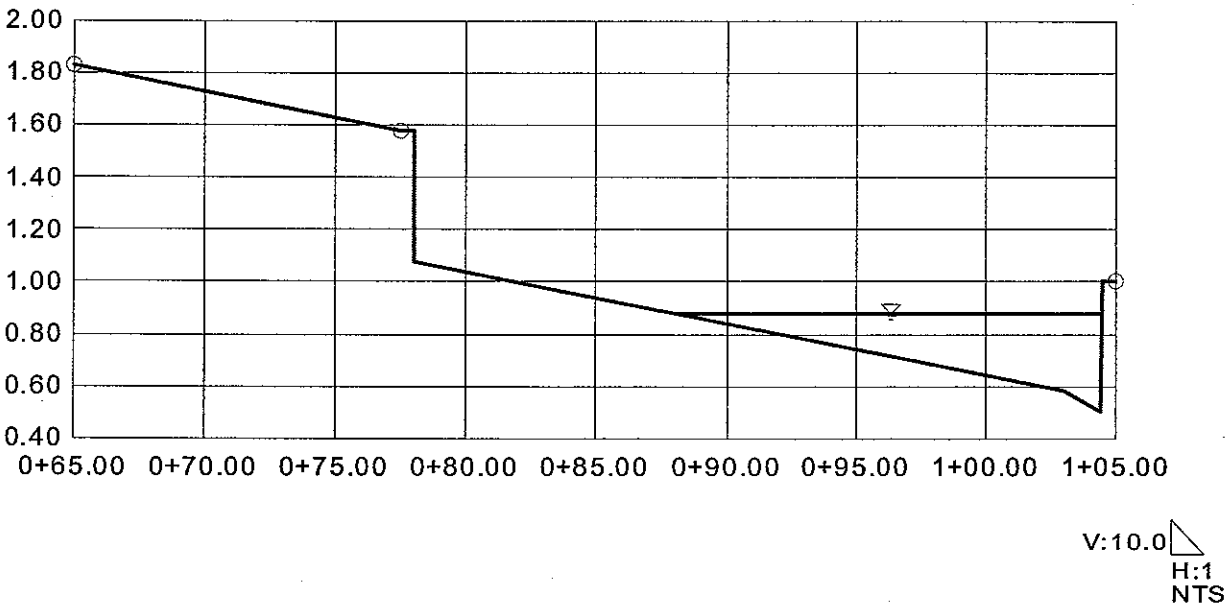
Natural Channel Points	
Station (ft)	Elevation (ft)
0+25.00	1.00
0+25.50	1.00
0+25.58	0.50
0+27.00	0.58
0+52.00	1.08
0+52.00	1.58
0+52.50	1.58
0+65.00	1.83

East Loop Road Sta. 175+00 - North Half - Roadway - Q10 = 8.5cfs

Cross Section for Irregular Channel

Project Description	
Worksheet	East Loop Road - North Half - Road
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficier	0.016	
Channel Slope	0.013000	ft/ft
Water Surface Elev	0.88	ft
Elevation Range	.50 to 1.83	
Discharge	8.50	cfs



East Loop Road Sta. 175+00 - North Half - Roadway - Q10 = 8.5cfs

Worksheet for Irregular Channel

Project Description	
Worksheet	East Loop Road - North Half - Road
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Channel Sl	013000	ft/ft
Discharge	8.50	cfs

Options	
Current Roughness Meth	ved Lotter's Method
Open Channel Weighting	ved Lotter's Method
Closed Channel Weightin	Horton's Method

Results		
Mannings Coefficie	0.016	
Water Surface Elev	0.88	ft
Elevation Range	).50 to 1.83	
Flow Area	2.7	ft²
Wetted Perimeter	16.68	ft
Top Width	16.35	ft
Actual Depth	0.38	ft
Critical Elevation	0.92	ft
Critical Slope	0.006695	ft/ft
Velocity	3.15	ft/s
Velocity Head	0.15	ft
Specific Energy	1.03	ft
Froude Number	1.36	
Flow Type	Supercritical	

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+65.00	0+77.50	0.035
0+77.50	1+05.00	0.016

Natural Channel Points

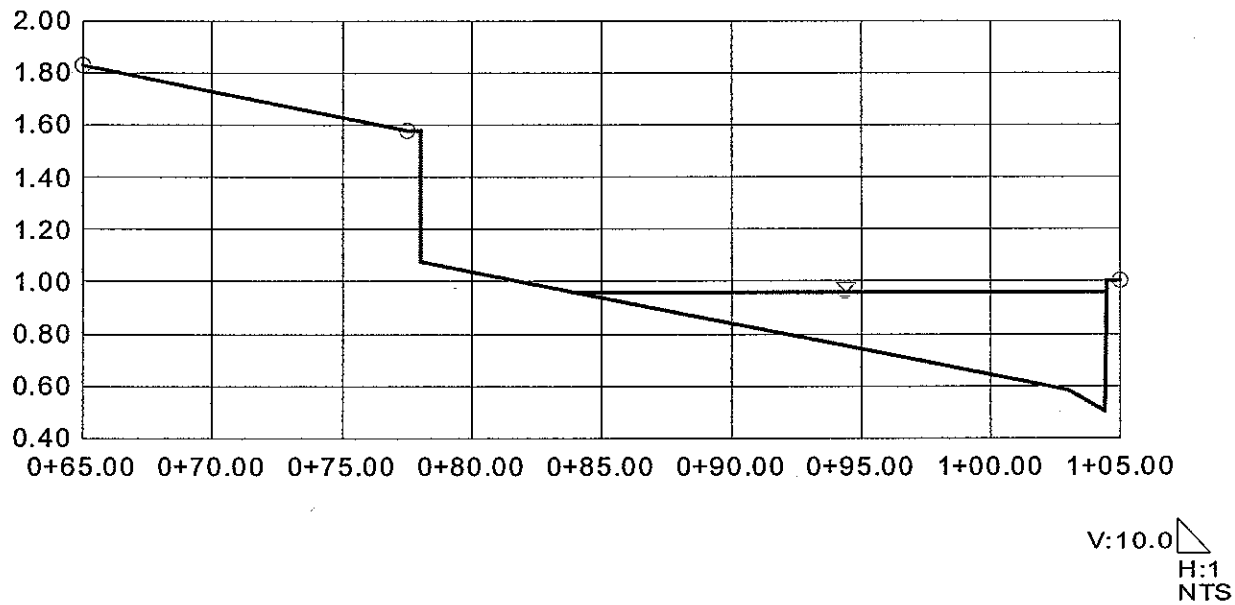
Station (ft)	Elevation (ft)
0+65.00	1.83
0+77.50	1.58
0+78.00	1.58
0+78.00	1.08
1+03.00	0.58
1+04.42	0.50
1+04.50	1.00
1+05.00	1.00

East Loop Road Sta. 175+00 - North Half - Roadway - Q100 = 15cfs

Cross Section for Irregular Channel

Project Description	
Worksheet	East Loop Road - North Half - Roadv
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficie	0.016	
Channel Slope	0.013000	ft/ft
Water Surface Elev	0.96	ft
Elevation Range	.50 to 1.83	
Discharge	15.00	cfs



East Loop Road Sta. 175+00 - North Half - Roadway - Q100 = 15cfs

Worksheet for Irregular Channel

Project Description	
Worksheet	East Loop Road - North Half - Road\
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Channel Sl	013000	ft/ft
Discharge	15.00	cfs

Options	
Current Roughness Meth	›ved Lotter's Method
Open Channel Weighting	›ved Lotter's Method
Closed Channel Weightin	Horton's Method

Results		
Mannings Coefficie	0.016	
Water Surface Elev	0.96	ft
Elevation Range	).50 to 1.83	
Flow Area	4.1	ft²
Wetted Perimeter	20.68	ft
Top Width	20.29	ft
Actual Depth	0.46	ft
Critical Elevation	1.02	ft
Critical Slope	0.006237	ft/ft
Velocity	3.62	ft/s
Velocity Head	0.20	ft
Specific Energy	1.16	ft
Froude Number	1.41	
Flow Type	Supercritical	

Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+65.00	0+77.50	0.035
0+77.50	1+05.00	0.016

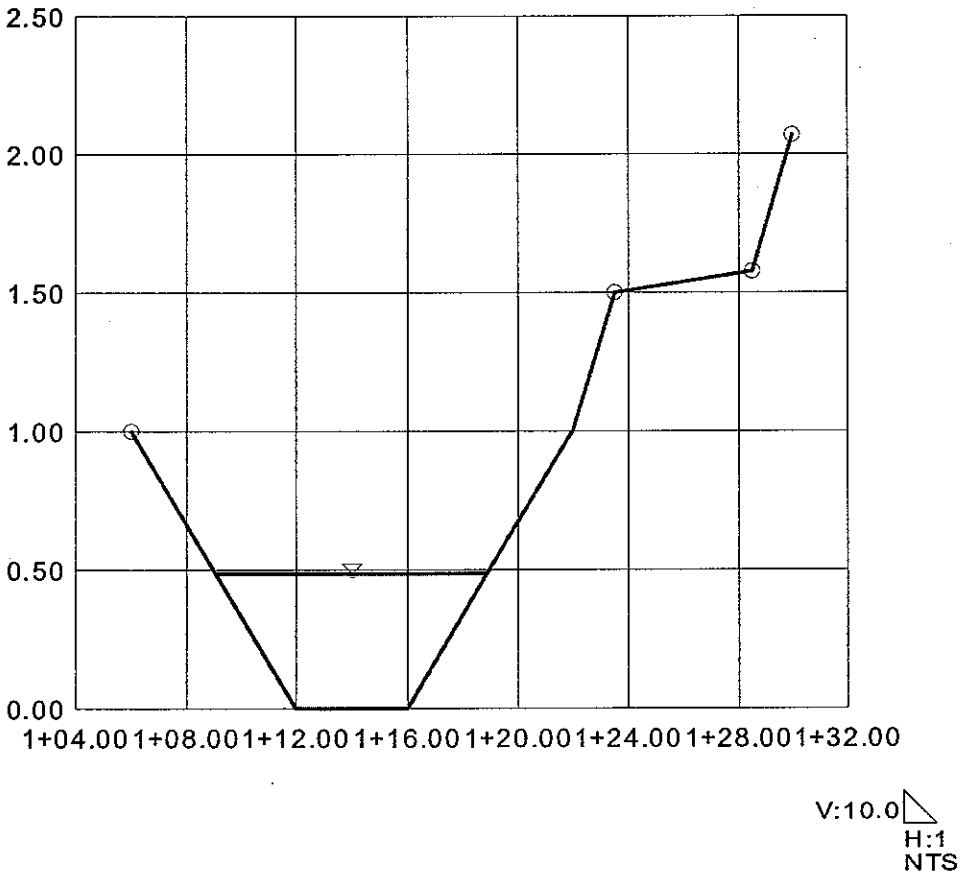
Natural Channel Points	
Station (ft)	Elevation (ft)
0+65.00	1.83
0+77.50	1.58
0+78.00	1.58
0+78.00	1.08
1+03.00	0.58
1+04.42	0.50
1+04.50	1.00
1+05.00	1.00

East Loop Road Sta. 175+00 - North Half - Swale - Q10 = 8cfs

Cross Section for Irregular Channel

Project Description	
Worksheet	East Loop Road - North Half - Swa
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficie	0.035	
Channel Slope	0.013000	ft/ft
Water Surface Elev	0.49	ft
Elevation Range	.00 to 2.08	
Discharge	8.00	cfs



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East Loop Road Sta 175+00 - North Half - Swale - Q10 = 8cfs

Worksheet for Irregular Channel

Project Description	
Worksheet	East Loop Road - North Half - Sw
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Channel Sl	013000	ft/ft
Discharge	8.00	cfs

Options	
Current Roughness Meth	oved Lotter's Method
Open Channel Weighting	oved Lotter's Method
Closed Channel Weightin	Horton's Method

Results		
Mannings Coefficie	0.035	
Water Surface Elev.	0.49	ft
Elevation Range	.00 to 2.08	
Flow Area	3.4	ft²
Wetted Perimeter	9.95	ft
Top Width	9.86	ft
Actual Depth	0.49	ft
Critical Elevation	0.40	ft
Critical Slope	0.027113	ft/ft
Velocity	2.36	ft/s
Velocity Head	0.09	ft
Specific Energy	0.58	ft
Froude Number	0.71	
Flow Type	Subcritical	

Roughness Segments

Start Station	End Station	Mannings Coefficient
1+06.00	1+23.50	0.035
1+23.50	1+28.50	0.016
1+28.50	1+30.00	0.035

Natural Channel Points

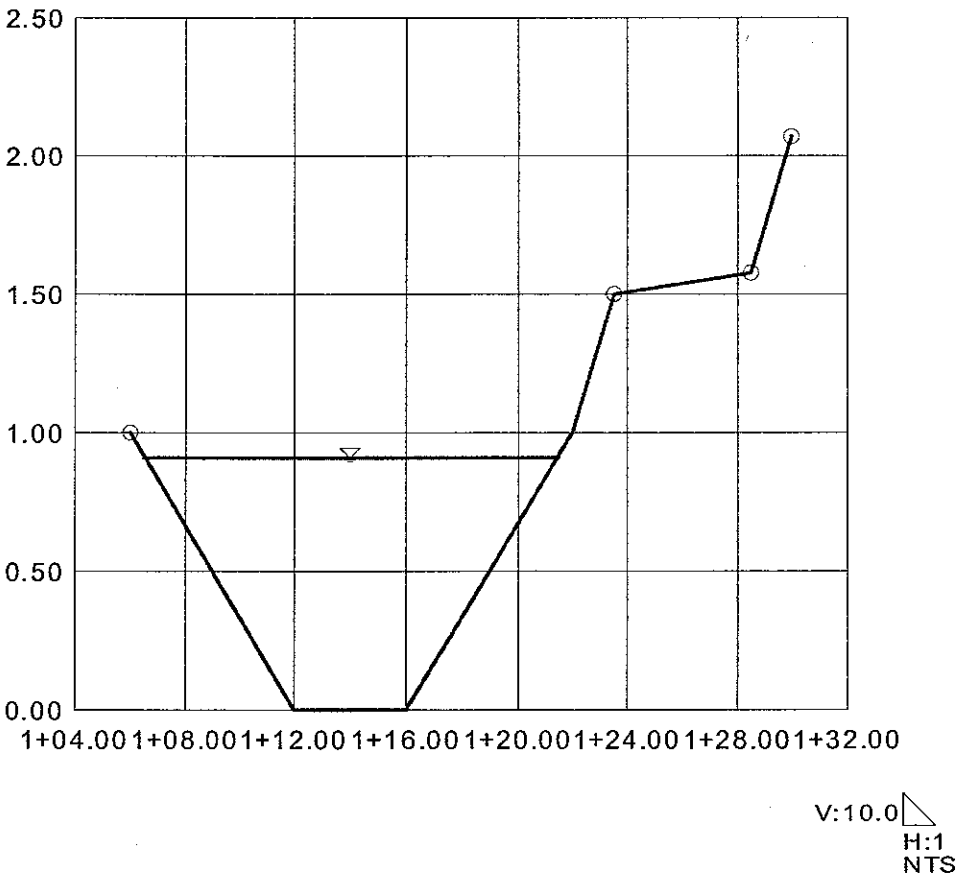
Station (ft)	Elevation (ft)
1+06.00	1.00
1+12.00	0.00
1+16.00	0.00
1+22.00	1.00
1+23.50	1.50
1+28.50	1.57
1+30.00	2.08

East Loop Road Sta. 175+00 - North Half - Swale - Q100 = 29cfs

Cross Section for Irregular Channel

Project Description	
Worksheet	East Loop Road - North Half - Swa
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficie	0.035	
Channel Slope	0.013000	ft/ft
Water Surface Elev	0.91	ft
Elevation Range	.00 to 2.08	
Discharge	29.00	cfs



East Loop Road Sta 175+00 - North Half - Swale - Q100 = 29cfs

Worksheet for Irregular Channel

Project Description	
Worksheet	East Loop Road - North Half - Swa
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Channel Sl	013000	ft/ft
Discharge	29.00	cfs

Options	
Current Roughness Meth	ved Lotter's Method
Open Channel Weighting	ved Lotter's Method
Closed Channel Weightin	Horton's Method

Results		
Mannings Coefficie	0.035	
Water Surface Elev	0.91	ft
Elevation Range	.00 to 2.08	
Flow Area	8.7	ft²
Wetted Perimeter	15.13	ft
Top Width	14.98	ft
Actual Depth	0.91	ft
Critical Elevation	0.80	ft
Critical Slope	0.022492	ft/ft
Velocity	3.34	ft/s
Velocity Head	0.17	ft
Specific Energy	1.09	ft
Froude Number	0.77	
Flow Type	Subcritical	

Roughness Segments

Start Station	End Station	Mannings Coefficient
1+06.00	1+23.50	0.035
1+23.50	1+28.50	0.016
1+28.50	1+30.00	0.035

Natural Channel Points

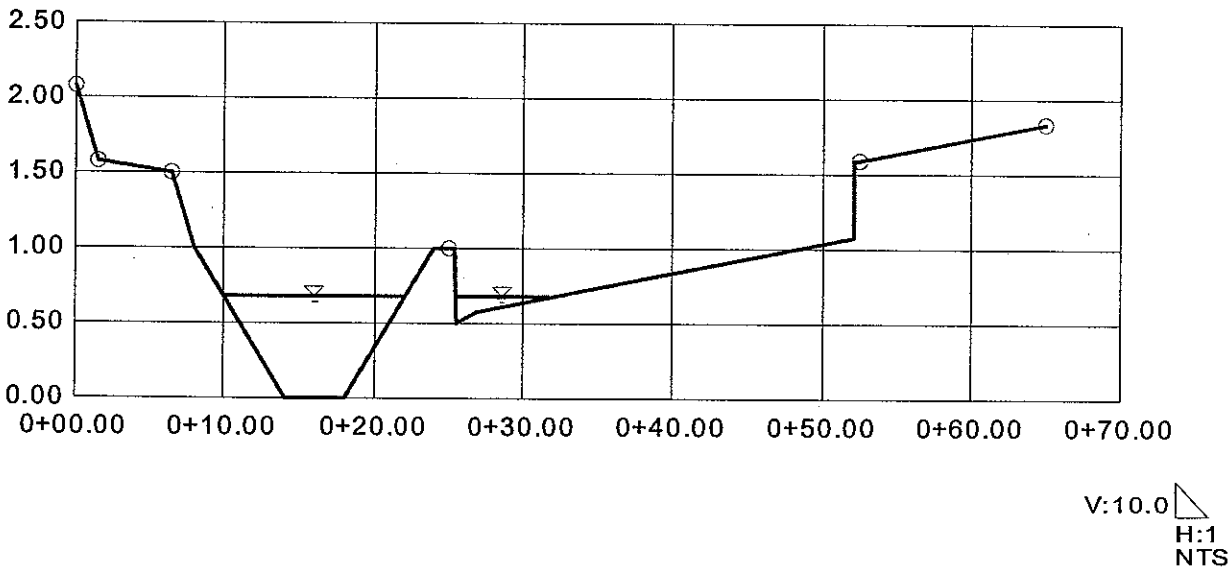
Station (ft)	Elevation (ft)
1+06.00	1.00
1+12.00	0.00
1+16.00	0.00
1+22.00	1.00
1+23.50	1.50
1+28.50	1.57
1+30.00	2.08

East Loop Road Sta. 191+00 - South Half - Q10 = 16cfs

Cross Section for Irregular Channel

Project Description	
Worksheet	East Loop Road - South Ha
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficier	0.029	
Channel Slope	0.013000	ft/ft
Water Surface Elev.	0.67	ft
Elevation Range	.00 to 2.08	
Discharge	16.00	cfs



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East Loop Road Sta. 191+00 - South Half - Q10 = 16cfs

Worksheet for Irregular Channel

Project Description	
Worksheet	East Loop Road - South Ha
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Channel Sl	013000	ft/ft
Discharge	16.00	cfs

Options	
Current Roughness Meth	ved Lotter's Method
Open Channel Weighting	ved Lotter's Method
Closed Channel Weightin	Horton's Method

Results		
Mannings Coefficie	0.029	
Water Surface Elev.	0.67	ft
Elevation Range	.00 to 2.08	
Flow Area	5.8	ft²
Wetted Perimeter	18.50	ft
Top Width	18.24	ft
Actual Depth	0.67	ft
Critical Elevation	0.62	ft
Critical Slope	0.017555	ft/ft
Velocity	2.74	ft/s
Velocity Head	0.12	ft
Specific Energy	0.79	ft
Froude Number	0.85	
Flow Type	Subcritical	

Calculation Messages:
Flow is divided.

Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00.00	0+01.50	0.035
0+01.50	0+06.50	0.016
0+06.50	0+25.00	0.035
0+25.00	0+52.50	0.016
0+52.50	0+65.00	0.035

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00.00	2.08
0+01.50	1.57
0+06.50	1.50
0+08.00	1.00
0+14.00	0.00
0+18.00	0.00

East Loop Road Sta. 191+00 - South Half - Q10 = 16cfs

Worksheet for Irregular Channel

Natural Channel Points	
Station (ft)	Elevation (ft)
0+24.00	1.00
0+25.00	1.00
0+25.50	1.00
0+25.58	0.50
0+27.00	0.58
0+52.00	1.08
0+52.00	1.58
0+52.50	1.58
0+65.00	1.83

East Loop Road Sta. 191+00 - South Half - Q10 = 16cfs

Rating Table for Irregular Channel

Project Description	
Worksheet	East Loop Road - South Ha
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Discharg	16.00 cfs

Options	
Current Roughness Metho	ved Lotter's Method
Open Channel Weighting	ved Lotter's Method
Closed Channel Weightin	Horton's Method

Attribute	Minimum	Maximum	Increment
Channel Slope (ft/ft)	0.013000	0.023000	0.005000

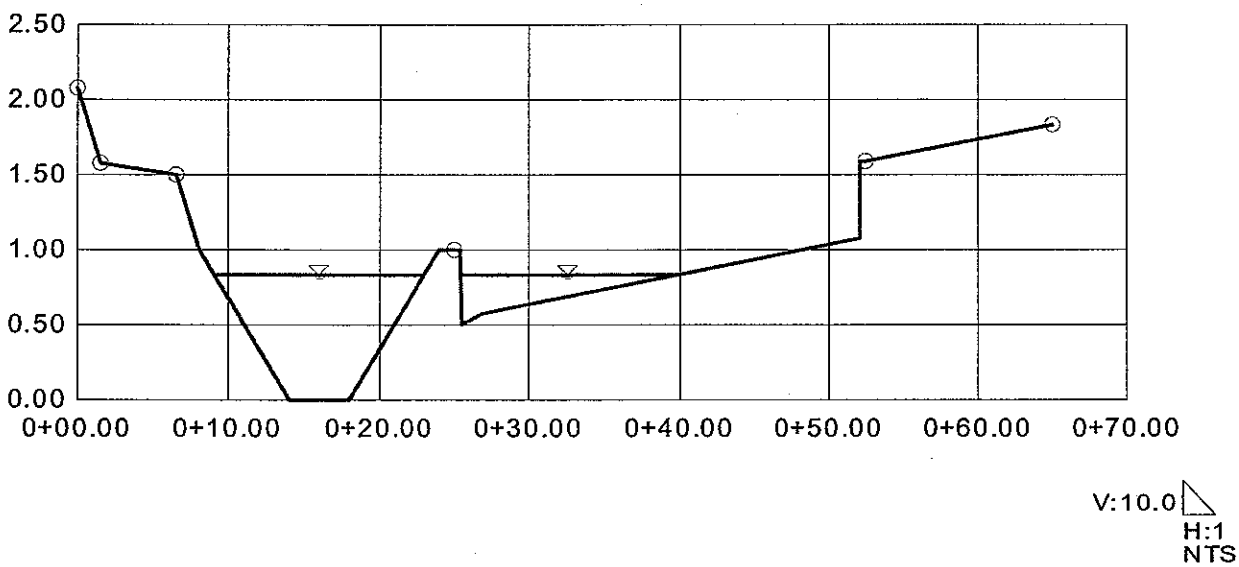
Channel Slope (ft/ft)	Water Surface Elevation (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
0.013000	0.67	2.74	5.8	18.50	18.24
0.018000	0.63	3.14	5.1	15.75	15.53
0.023000	0.60	3.47	4.6	13.62	13.44

East Loop Road Sta. 191+00 - South Half - Q100 = 29.5cfs

Cross Section for Irregular Channel

Project Description	
Worksheet	East Loop Road - South Hal
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficier	0.026	
Channel Slope	0.013000	ft/ft
Water Surface Elev.	0.83	ft
Elevation Range	.00 to 2.08	
Discharge	29.50	cfs



East Loop Road Sta. 191+00 - South Half - Q100 = 29.5cfs
Worksheet for Irregular Channel

Project Description	
Worksheet	East Loop Road - South Hal
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Channel Sl	013000	ft/ft
Discharge	29.50	cfs

Options	
Current Roughness Meth	ved Lotter's Method
Open Channel Weighting	ved Lotter's Method
Closed Channel Weightin	Horton's Method

Results		
Mannings Coefficie	0.026	
Water Surface Elev	0.83	ft
Elevation Range	.00 to 2.08	
Flow Area	9.5	ft²
Wetted Perimeter	28.51	ft
Top Width	28.08	ft
Actual Depth	0.83	ft
Critical Elevation	0.81	ft
Critical Slope	0.014756	ft/ft
Velocity	3.10	ft/s
Velocity Head	0.15	ft
Specific Energy	0.98	ft
Froude Number	0.94	
Flow Type	Subcritical	

Calculation Messages:
Flow is divided.

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00.00	0+01.50	0.035
0+01.50	0+06.50	0.016
0+06.50	0+25.00	0.035
0+25.00	0+52.50	0.016
0+52.50	0+65.00	0.035

Natural Channel Points

Station (ft)	Elevation (ft)
0+00.00	2.08
0+01.50	1.57
0+06.50	1.50
0+08.00	1.00
0+14.00	0.00
0+18.00	0.00

East Loop Road Sta. 191+00 - South Half - Q100 = 29.5cfs

Worksheet for Irregular Channel

Natural Channel Points	
Station (ft)	Elevation (ft)
0+24.00	1.00
0+25.00	1.00
0+25.50	1.00
0+25.58	0.50
0+27.00	0.58
0+52.00	1.08
0+52.00	1.58
0+52.50	1.58
0+65.00	1.83

East Loop Road Sta. 191+00 - South Half - Q100 = 29.5cfs

Rating Table for Irregular Channel

Project Description	
Worksheet	East Loop Road - South Hal
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Discharg	29.50 cfs

Options	
Current Roughness Meth	ved Lotter's Method
Open Channel Weighting	ved Lotter's Method
Closed Channel Weightin	Horton's Method

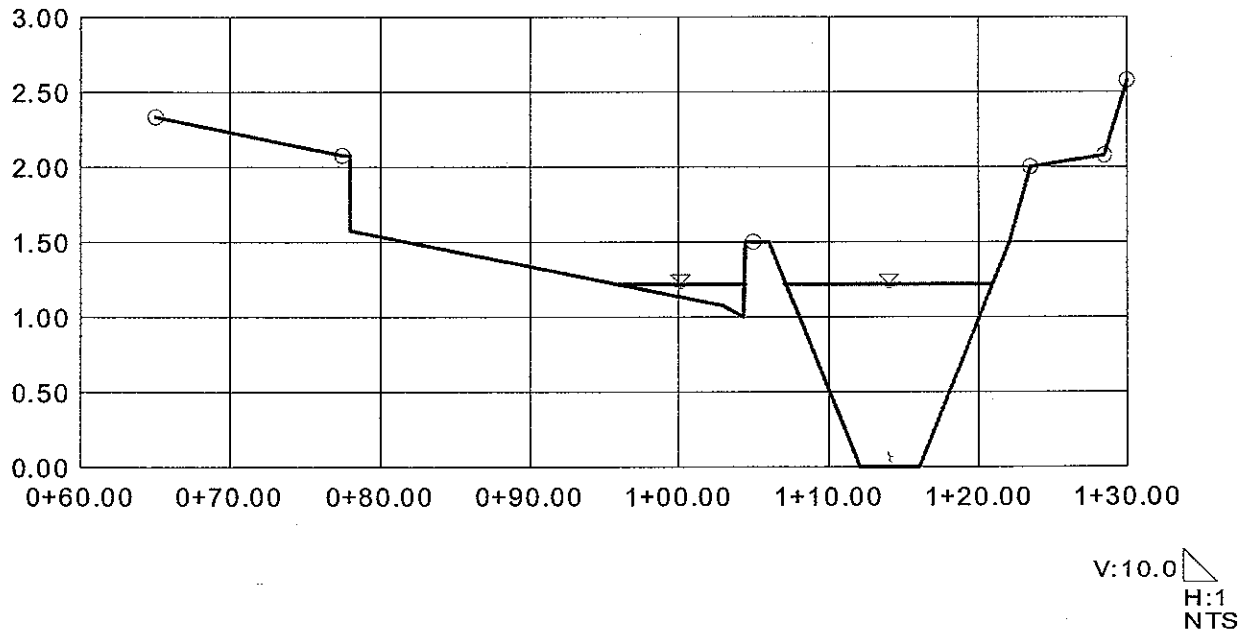
Attribute	Minimum	Maximum	Increment
Channel Slope (ft/ft)	0.013000	0.023000	0.005000

Channel Slope (ft/ft)	Water Surface Elevation (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
0.013000	0.83	3.10	9.5	28.51	28.08
0.018000	0.79	3.52	8.4	25.86	25.47
0.023000	0.76	3.88	7.6	23.87	23.52

East Loop Road Sta. 191+00 - North Half - Q10 = 46cfs
Cross Section for Irregular Channel

Project Description	
Worksheet	East Loop Road - North Hal
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficie	0.027	
Channel Slope	0.013000	ft/ft
Water Surface Elev	1.22	ft
Elevation Range	.00 to 2.58	
Discharge	46.00	cfs



East Loop Road Sta 191+00 - North Half - Q10 = 46cfs
Worksheet for Irregular Channel

Project Description	
Worksheet	East Loop Road - North Hal
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Channel Sl	013000	ft/ft
Discharge	46.00	cfs

Options	
Current Roughness Meth	ved Lotter's Method
Open Channel Weighting	ved Lotter's Method
Closed Channel Weightin	Horton's Method

Results		
Mannings Coefficie	0.027	
Water Surface Elev.	1.22	ft
Elevation Range	.00 to 2.58	
Flow Area	11.7	ft²
Wetted Perimeter	22.93	ft
Top Width	22.43	ft
Actual Depth	1.22	ft
Critical Elevation	1.20	ft
Critical Slope	0.013899	ft/ft
Velocity	3.94	ft/s
Velocity Head	0.24	ft
Specific Energy	1.47	ft
Froude Number	0.96	
Flow Type	Subcritical	

Calculation Messages:
Flow is divided.

Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+65.00	0+77.50	0.035
0+77.50	1+05.00	0.016
1+05.00	1+23.50	0.035
1+23.50	1+28.50	0.016
1+28.50	1+30.00	0.035

Natural Channel Points	
Station (ft)	Elevation (ft)
0+65.00	2.33
0+77.50	2.08
0+78.00	2.08
0+78.00	1.58
1+03.00	1.08
1+04.42	1.00

East Loop Road Sta 191+00 - North Half - Q10 = 46cfs
Worksheet for Irregular Channel

Natural Channel Points	
Station (ft)	Elevation (ft)
1+04.50	1.50
1+05.00	1.50
1+06.00	1.50
1+12.00	0.00
1+16.00	0.00
1+22.00	1.50
1+23.50	2.00
1+28.50	2.08
1+30.00	2.58

East Loop Road Sta. 191+00 - North Half - Q10 = 46cfs
Rating Table for Irregular Channel

Project Description	
Worksheet	East Loop Road - North Hal
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Discharg	46.00 cfs

Options	
Current Roughness Meth	ved Lotter's Method
Open Channel Weighting	ved Lotter's Method
Closed Channel Weightin	Horton's Method

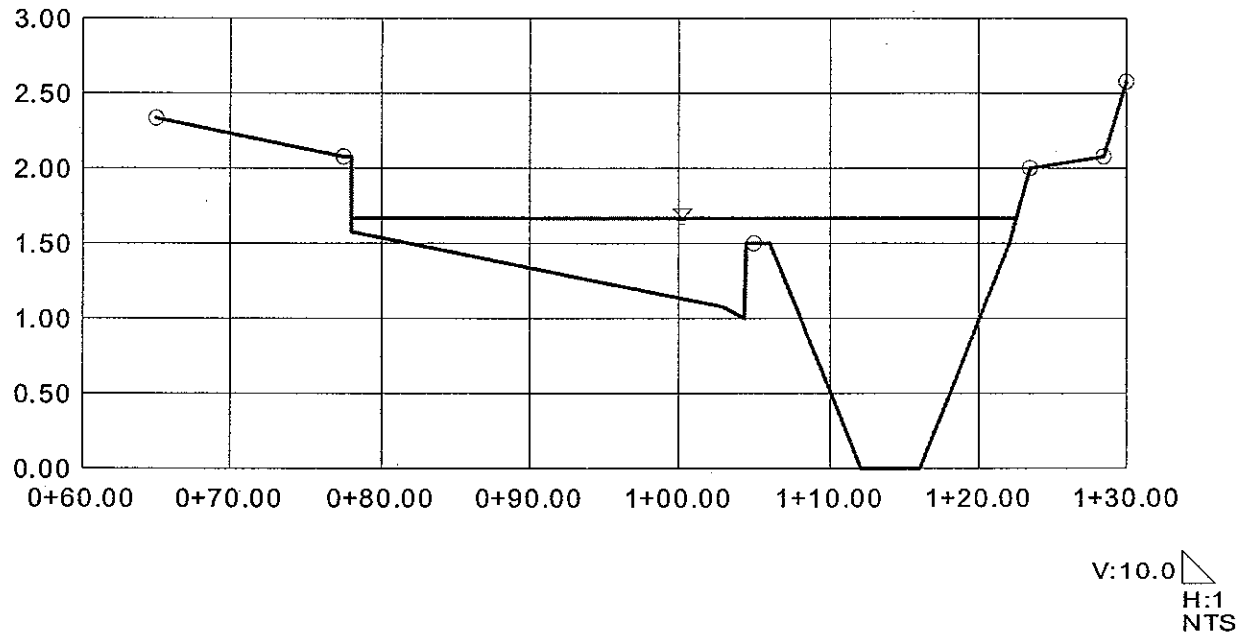
Attribute	Minimum	Maximum	Increment
Channel Slope (ft/ft)	0.013000	0.023000	0.005000

Channel Slope (ft/ft)	Water Surface Elevation (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
0.013000	1.22	3.94	11.7	22.93	22.43
0.018000	1.15	4.55	10.1	18.35	17.94
0.023000	1.09	5.05	9.1	14.71	14.37

East Loop Road Sta. 191+00 - North Half - Q100 = 135.5cfs
Cross Section for Irregular Channel

Project Description	
Worksheet	East Loop Road - North Half
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficier	0.024	
Channel Slope	0.013000	ft/ft
Water Surface Elev.	1.67	ft
Elevation Range	.00 to 2.58	
Discharge	135.50	cfs



East Loop Road Sta 191+00 - North Half - Q100 = 135.5cfs
Worksheet for Irregular Channel

Project Description	
Worksheet	East Loop Road - North Half
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Channel Sl	013000	ft/ft
Discharge	135.50	cfs

Options	
Current Roughness Metho	oved Lotter's Method
Open Channel Weighting	oved Lotter's Method
Closed Channel Weightin	Horton's Method

Results		
Mannings Coefficie	0.024	
Water Surface Elev.	1.67	ft
Elevation Range	0.00 to 2.58	
Flow Area	27.3	ft²
Wetted Perimeter	45.42	ft
Top Width	44.50	ft
Actual Depth	1.67	ft
Critical Elevation	1.71	ft
Critical Slope	0.010214	ft/ft
Velocity	4.96	ft/s
Velocity Head	0.38	ft
Specific Energy	2.05	ft
Froude Number	1.12	
Flow Type	Supercritical	

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+65.00	0+77.50	0.035
0+77.50	1+05.00	0.016
1+05.00	1+23.50	0.035
1+23.50	1+28.50	0.016
1+28.50	1+30.00	0.035

Natural Channel Points

Station (ft)	Elevation (ft)
0+65.00	2.33
0+77.50	2.08
0+78.00	2.08
0+78.00	1.58
1+03.00	1.08
1+04.42	1.00
1+04.50	1.50
1+05.00	1.50
1+06.00	1.50

East Loop Road Sta 191+00 - North Half - Q100 = 135.5cfs

Worksheet for Irregular Channel

Natural Channel Points	
Station (ft)	Elevation (ft)
1+12.00	0.00
1+16.00	0.00
1+22.00	1.50
1+23.50	2.00
1+28.50	2.08
1+30.00	2.58

East Loop Road Sta. 191+00 - North Half - Q100 = 135.5cfs

Rating Table for Irregular Channel

Project Description	
Worksheet	East Loop Road - North Half
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Discharge	35.50 cfs

Options	
Current Roughness Meth	oved Lotter's Method
Open Channel Weighting	oved Lotter's Method
Closed Channel Weightin	Horton's Method

Attribute	Minimum	Maximum	Increment
Channel Slope (ft/ft)	0.013000	0.023000	0.005000

Channel Slope (ft/ft)	Water Surface Elevation (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
0.013000	1.67	4.96	27.3	45.42	44.50
0.018000	1.61	5.48	24.7	45.18	44.33
0.023000	1.57	5.94	22.8	44.29	43.47

APPENDIX C

REFERENCES

KINGMAN AREA MASTER DRAINAGE PLAN DESIGN AND ADMINISTRATIVE MANUAL 36,

7. STREET DRAINAGE

STREET FLOW CRITERIA

7.1 ALLOWABLE INUNDATION OF STREETS

Design standards for the collection and conveying of runoff water on public streets is based on an acceptable frequency of traffic interference. That is, depending on the width (and hence classification) of the street, certain traffic lanes can be fully inundated after exceeding the design storm frequency.

Street drainage shall be governed by Table 7.1.

Table 7.1 Design Storm Frequencies for Street Drainage (Years)

LONGITUDINAL STREET FLOW	
No curb overtopping * (For 4 or more laned streets at least 1 traffic lane free of water in each direction.)	10
Flow to be calculated assuming contained in right-of-way with top water elevation within 1 foot of lowest finished floors.	100
CROSS STREET FLOW	
No flow across streets **	10
1.0 feet of depth at crown	100

* Where no curb exists, maximum depth to be 0.5 feet over crown
** Except at designated dip crossings.

Regardless of the size of the culvert, bridge or dipped section, the street crossing is to be designed to convey the 100-year storm runoff under and/or over the road to an area downstream of the crossing to which the flow would have gone in the absence of the street crossing.

For flows crossing broad shallow washes where the construction of a culvert is not practical or desirable, the road should be dipped to allow the entire flow across the road. The pavement through the dip should have a one way slope and curbing and medians must not be raised. For these situations approval is to be obtained from the ENGINEER.

7.2 GUTTER FLOW

Longitudinal street flow for events less than the 10 year recurrence interval will frequently be contained within the street section by the curb and gutter. The calculation of a theoretical gutter capacity can be performed using Manning's equation as previously presented. Because splashing,waves from traffic and cars parked in the gutter frequently reduce the actual gutter capacity, a reduction factor must be applied to theoretical flow to determine actual gutter capacity. Figure 7-1 presents a nomograph for allowable gutter capacity and already includes a reduction factor.

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Figure 2.5
AREA VERSUS PATTERN NUMBER FOR MARICOPA COUNTY

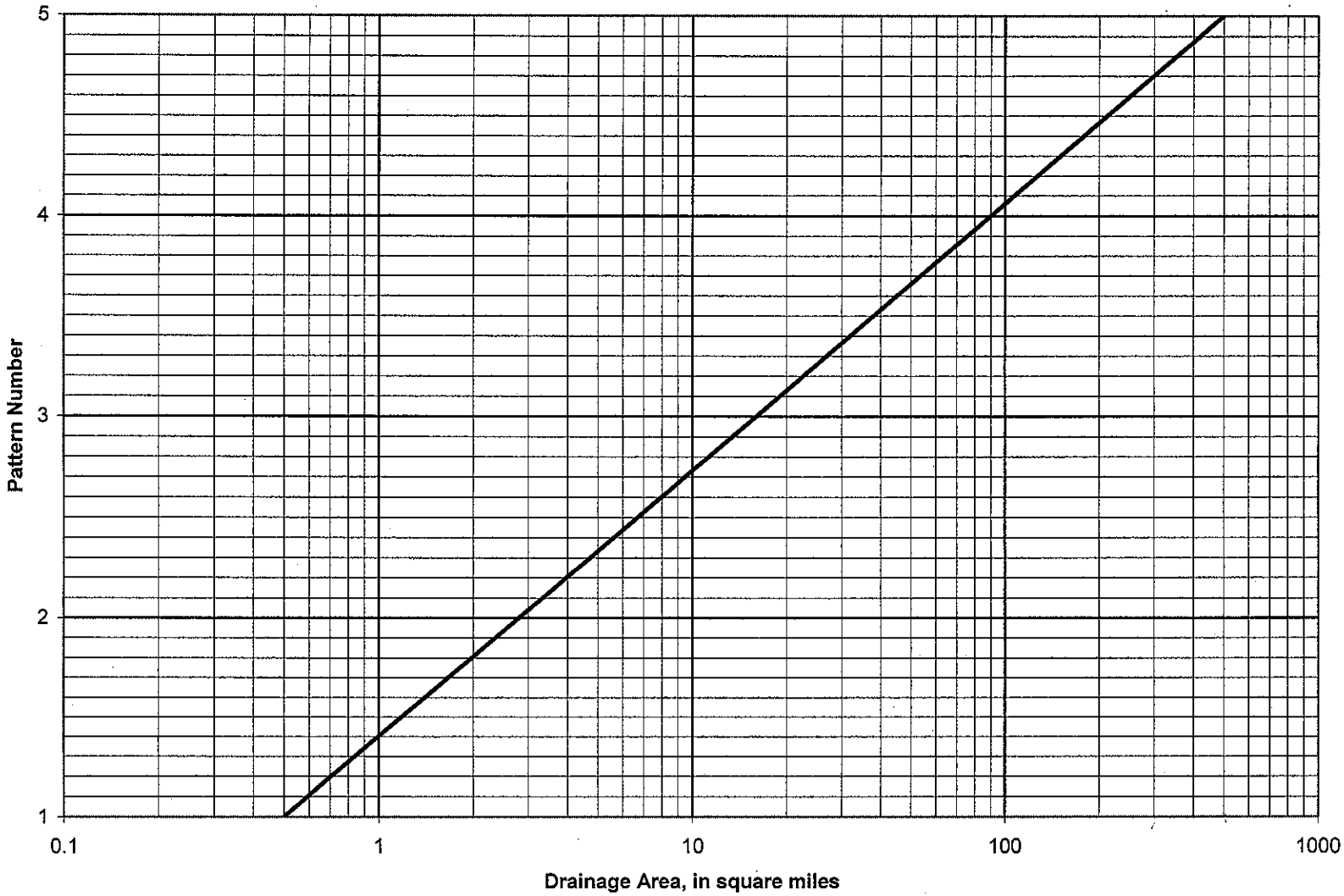


Table 2.4
6-HOUR DISTRIBUTIONS

	Percent of Rainfall Depth*				
Time, in hours	**Pattern 1**	**Pattern 2**	**Pattern 3**	**Pattern 4**	**Pattern 5**
0:00	0.0	0.0	0.0	0.0	0.0
0:15	0.8	0.9	1.5	2.1	2.4
0:30	1.6	1.6	2.0	3.5	4.3
0:45	2.5	2.5	3.0	5.1	5.9
1:00	3.3	3.4	4.8	7.1	7.8
1:15	4.1	4.2	6.3	8.7	9.8
1:30	5.0	5.1	7.6	10.5	11.9
1:45	5.8	5.9	9.0	12.5	14.1
2:00	6.6	6.7	10.5	14.3	16.2
2:15	7.4	7.6	11.9	16.0	18.6
2:30	8.7	8.7	13.5	17.9	21.2
2:45	9.9	10.0	15.2	20.1	23.9
3:00	11.8	12.0	17.5	23.2	27.1
3:15	13.8	16.3	22.2	28.1	32.1
3:30	21.6	25.2	30.4	36.4	40.8
3:45	37.7	45.1	47.2	50.0	51.5
4:00	83.4	69.4	67.0	65.8	62.7
4:15	91.1	83.7	79.6	77.3	73.5
4:30	93.1	90.0	86.8	84.1	81.4
4:45	95.0	93.8	91.2	88.8	86.4
5:00	96.2	95.0	94.6	92.7	90.7
5:15	97.2	96.3	96.0	94.5	93.0
5:30	98.3	97.5	97.3	96.4	95.4
5:45	99.1	98.8	98.7	98.2	97.7
6:00	100.0	100.0	100.0	100.0	100.0

*Pattern represents percent Rainfall Depth.

FIGURE 10-16

SCATTER DIAGRAM OF INDEPENDENT VARIABLES FOR R10 REGRESSION EQUATI

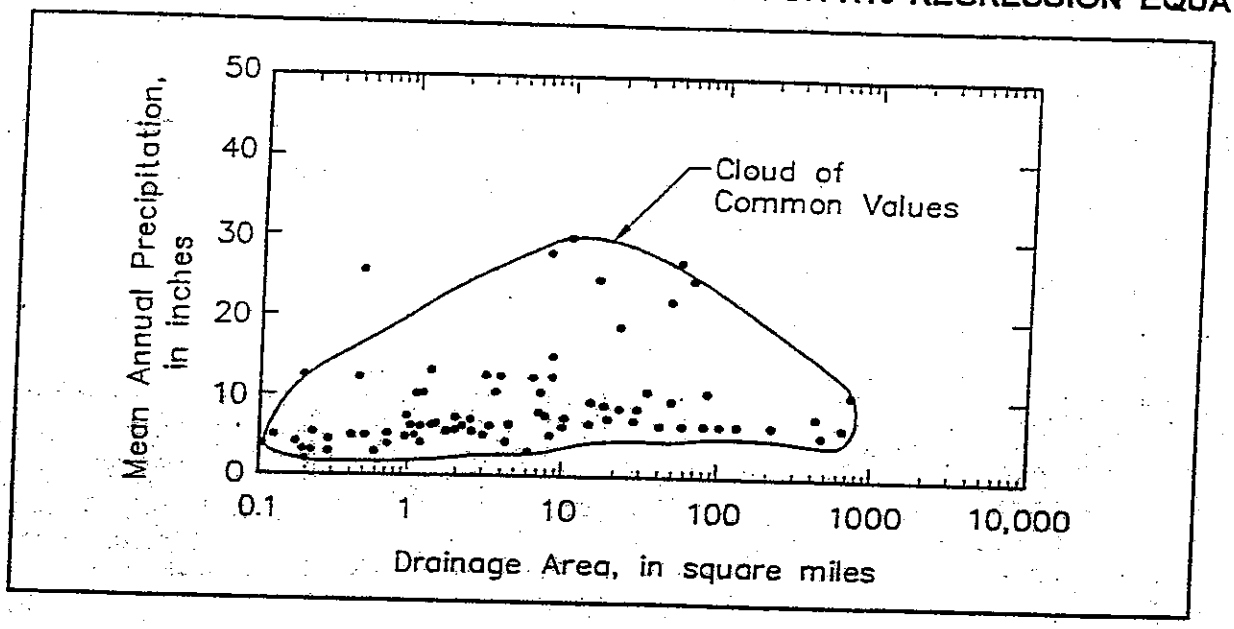
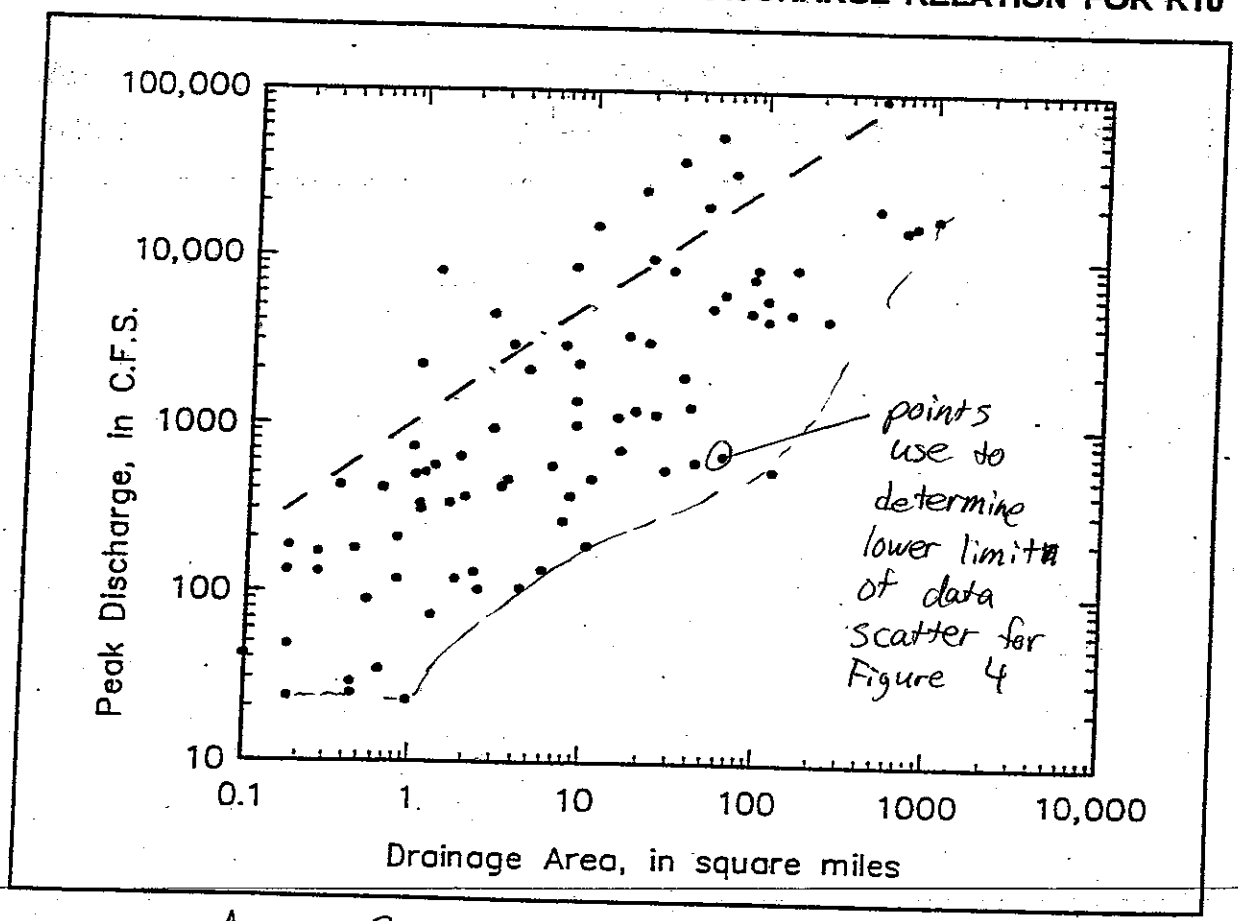


FIGURE 10-17

Q_{100} DATA POINTS AND 100-YEAR PEAK DISCHARGE RELATION FOR R10



Arizona Department of Transportation Drainage Design Manual

3.3. Design Storm and Precipitation

Local jurisdiction requires that water sheds less than 20 square miles be evaluated for the 6-hour local storm. Drainage sheds of 20 to 100 square miles are to be evaluated for both the 6-hour and 24-hour rainfall events. Areas from 20 square miles to 500 square miles are considered general storms and are evaluated for the 24-hour precipitation.

Maricopa County Flood Control District has developed storm distribution curves associated with drainage shed size. Since the total area of Section 3, is less than 0.5 square miles, Pattern 1 of the Maricopa County 6-Hour Mass Curve was utilized for the storm distribution. Precipitation values of 2.98-inches and 1.74-inches were taken from the National Oceanographic and Atmospheric Administration National Weather Service's Atlas 14. Table 1 provides the precipitation values from NOAA Atlas 14. Since the total water-shed area of considered in this study is 0.16 square miles (102 acres) the depth-area reduction factor was not applied.

Table 1 - Precipitation

Recurrence Interval (yrs)	5 min	10-min	15-min	30-min	1-hr	2-hr	3-hr	6-hr
10-yr	0.39	0.60	0.74	1.00	1.24	1.42	1.51	1.74
100-yr	0.64	0.97	1.20	1.62	2.00	2.42	2.65	2.98

3.4. Soils

Soils information is taken from the Natural Resources Conservation Service, Soil Data Mart. Soils within the water-shed in this study consist of Lostman Gravelly Sandy Loam, Moist (AZ627) type. These soils have a hydrologic soil type designation of "B".

3.5. Hydrologic Model Data and Results

Table 2 summarizes runoff at the junction point and drainage sheds analyzed in this study for the Future Condition. The lower flows at junction J-S5 for the predeveloped condition were not calculated because the flows from basin S3-2 are not included. Runoff values are rounded to the nearest 1 cfs.

Table 2 – Future Condition Flow Summary

Element	Area (sq mi)	Peak Discharge 100-yr (cfs)	Peak Discharge 10-yr (cfs)
OS-3	0.0276	29	8
S3-2	0.0104	30	17
S3-1	0.0074	23	13
P3-45	0.0025	3	1
OS-4	0.1115	80	23
J-S3A	0.1594	116	41

It should be noted that the precipitation depths of the 100-yr, 6-hr event is 2.98-inches and that the precipitation depth of the 10-yr, 6-hr storm is 1.74-inches. For the same events the amount of excess precipitation available for runoff is dependent on the runoff curve number, which is a function of soil type, land use, and antecedent moisture conditions. For this reason a larger portion of the 100-yr precipitation is available for runoff than for the smaller 10-yr storm and the ratio of peak runoff for the 100-yr precipitation to 10-yr precipitations is nearly 3.

All model results and input data are found in the Appendices of this study. They consist of the following:

- Appendix A – Model Results and Data provides the input parameters and results for Section 3 sub-sheds.
- Appendix B – Street Normal Depth Calculations provides the street and drainage swale capacity calculations within Section 3.
- Appendix C – References

3.6. Section 3 Flow Capacity

Normal depth calculations were made at sections located at station 191+00 and station 175+00, the west and east limits of the East Loop Road Section 3, respectively. These calculations were made to show that the worst case flows calculated from the Future Conditions Analysis can be conveyed within East Loop Road while satisfying flood control criteria established by the Kingman Area Master Drainage Plan Design and Administrative Manual which includes providing for one traffic lane free of water in each direction in the 10-yr, 6-hr storm event. Flows used in the calculations are an algebraic sum of the peak flows from the contributing sub-sheds. Please note that the algebraic sum of 100-yr flows combining at J-S3A equals 165 cfs (135.5 cfs in the north half of the East Loop Road and 29.5 cfs in the south half of the East Loop Road) while the peak 100-yr flow is 116 cfs.

The 10-yr and 100-yr normal depth calculations for the section at 175+00 are broken into three parts: *East Loop Road Sta. 175+00 – South Half – Roadway, East Loop Road Sta. 175+00 – North Half – Roadway, East Loop Road Sta. 175+00 – North Half – Swale*. For conservative results, the 10-yr and 100-yr flows of 8.5 cfs and 15 cfs, respectively, used in the south and north half roadway calculations are half of the flows generated by sub-shed S3-2 which overlaps the swale. The 10-yr and 100-yr flows of 8 cfs and 29 cfs, respectively, used for the north half swale calculation are generated by sub-shed OS-3.

The 10-yr and 100-yr normal depth calculations for the section at 191+00 are broken into two parts: *East Loop Road Sta. 191+00 – South Half, East Loop Road Sta. 191+00 – North Half.* 10-yr and 100-yr flows of 16 cfs and 29.5 cfs, respectively, from half of sub-sheds S3-1 and S3-2 and sub-shed P3-45 are used for the south half calculation. The north half calculation includes 10-yr and 100-yr flows of 46 cfs and 135.5 cfs, respectively, from half of sub-sheds S3-1 and S3-2 and sub-sheds OS-3 and OS-4. Flow depths for the roadway and swale were calculated with one section for the south and north halves at station 191+00 because the water surface within the swale is above the flow line of the curb and gutter at the locations of the scuppers. Flows within the north swale and roadway approaching station 175+00 are not connected and were therefore

analyzed separately. Full section calculations were not performed as there is no flow over topping along the centerline of the East Loop Road.

The results for these calculations are included in Appendix B.

4. COMPARISON OF FLOWS

The drainage shed characteristics change with development of existing lands. The pervious soils that formerly existed become less pervious with the addition of houses, streets, and sidewalks and the time for runoff to reach its release point shortens. Table 3 provides a comparison of 100-yr existing generated runoff based on the regression equation developed for Arizona Region 10 conditions ($Q = 850A^{0.69}$) by the Arizona Department of Water Resources and 100-yr runoff results from the HEC-HMS model. The area (A) in the regression equation is in square miles, the flows (Q) for both methods are in cubic feet per second. Figure 4, *Flow Comparison,* shows this relationship and the lower envelope limits of discharge vs. area graph as presented in Figure 10-17 of the Arizona Department of Transportation Highway Drainage Design Manual. The values calculated by HEC-HMS are within the envelope of the data points used in determining the regression equation.

Table 3 – Flow Comparison

Shed	Area (mi^2)	Regression Equation Flow (cfs)	HEC-HMS Flow (cfs)
OS-3	0.0276	71	29
S3-2	0.0104	36	30
S3-1	0.0074	29	23
P3-45	0.0025	14	3
OS-4	0.1150	187	80
J-S3A	0.1629	239	116

Figure 4 – Section 3 Flow Comparison

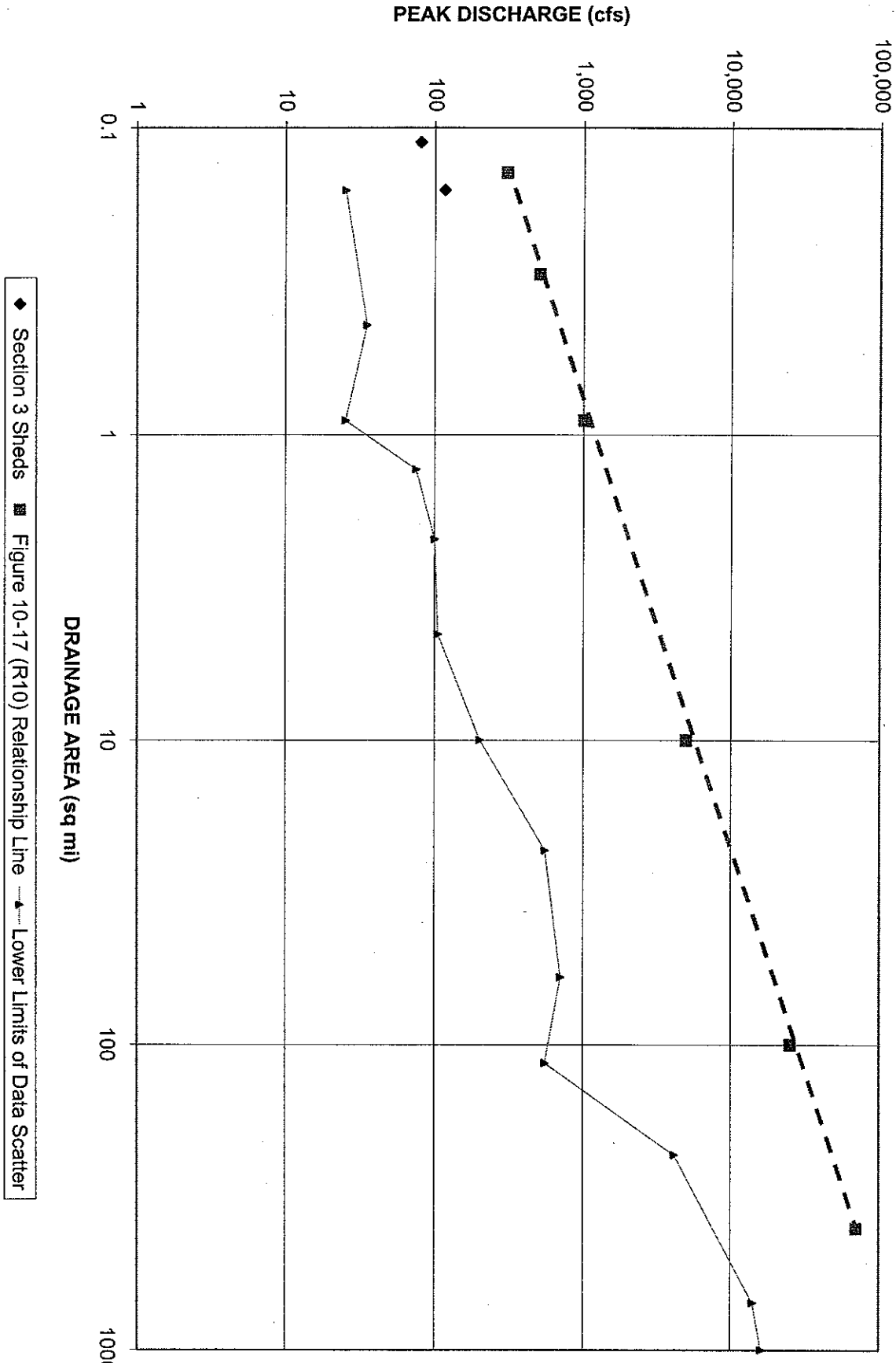


Figure 4
Flow Comparison

5. SUMMARY

The calculated flows satisfy specific criteria for the development of Section 3 of East Loop Road.

- The runoff can be maintained and conveyed within the street right-of-way and adjacent utility easements.
- One traffic lane will be free of water in each direction in the 10-yr, 6-hr storm event (minimum).
- Finished floor elevations in the adjacent Area 3 development are greater than one foot above the calculated water surface elevations.

6. REFERENCES

1) *Flood Insurance Rate Map*, Community Panel Number 040058 2325 C, Mohave County, Arizona, effective October 20, 2002.
2) *Kingman Area Master Drainage Plan Design and Administrative Manual*, Boyle Engineering Corporation, June, 1988.
3) *Drainage Design Manual for Maricopa County, Arizona*, Hydrology: Rainfall, Flood Control District of Maricopa County, November 2003.
4) *Highway Drainage Design Manual,* Arizona Department of Transportation, Report Number FHWA-AZ93-281, Final Report, March, 1993.
5) *Requirement for Floodplain and Floodway Delineation in Riverine Environments,* Arizona Department of Water Resources, Flood Mitigation Section, State Standard 2-96, July 1996.
6) *Technical Drainage Study for Golden Valley Ranch Mohave County, AZ,* Stanley Consultants Inc., October 2005.
7) *Technical Drainage Study for Golden Valley Ranch Mohave County, AZ Area 3,* Stanley Consultants Inc., March 2006
8) *SCS TR-55,* USDA, June 1986

APPENDIX A

HYDROLOGIC ANALYSIS

- HEC-HMS 100-yr, 6-hr Simulation
- HEC-HMS 10-yr, 6-hr Simulation
- NOAA Atlas 14 – Precipitation
- Accumulated 6-Hour Precipitation Depths
- Time of Concentration (STANDARD FORM 4) and Weighted Curve Number Derivation

Project: Sec3_HECHMS Simulation Run: Sec3 100-yr

Start of Run:	01Jan3000, 01:00	Basin Model:	Section 3
End of Run:	02Jan3000, 01:55	Meteorologic Model:	S-Pattern 1(2.98in)
Compute Time:	01Jun2006, 10:10:06	Control Specifications:	Control 1

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
J-S3A	0.1594	115.97	01Jan3000, 05:20	10.48
OS-3	0.0276	28.58	01Jan3000, 05:15	1.56
OS-4	0.1115	79.71	01Jan3000, 05:30	6.29
P3-45	0.0025	3.02	01Jan3000, 05:10	0.12
S3-1	0.0074	22.93	01Jan3000, 05:05	1.04
S3-2	0.0104	29.79	01Jan3000, 05:05	1.48

Project: Sec3_HECHMS Simulation Run: Sec3 10yr

Start of Run:	01Jan3000, 01:00	Basin Model:	Section 3
End of Run:	02Jan3000, 01:55	Meteorologic Model:	S-Pattern 1(1.74in)
Compute Time:	01Jun2006, 10:10:11	Control Specifications:	Control 1

Volume Units: AC-FT

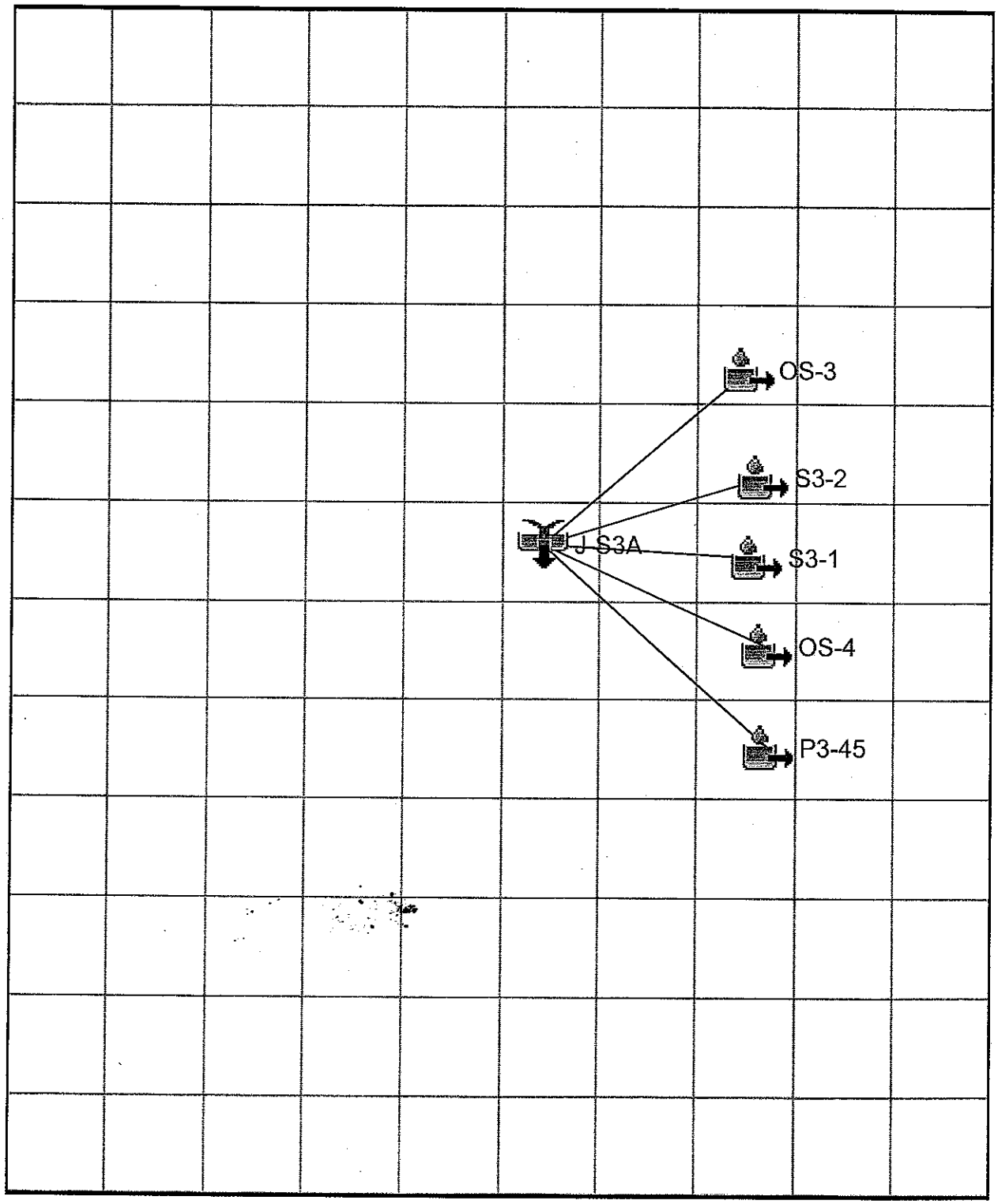
Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
J-S3A	0.1594	41.36	01Jan3000, 05:10	3.73
OS-3	0.0276	8.27	01Jan3000, 05:20	0.47
OS-4	0.1115	23.07	01Jan3000, 05:35	1.88
P3-45	0.0025	0.77	01Jan3000, 05:10	0.03
S3-1	0.0074	12.71	01Jan3000, 05:05	0.56
S3-2	0.0104	16.51	01Jan3000, 05:05	0.80

HEC-HMS

Project : Sec3_HECHMS

Basin Model : Section 3

Jun 01 10:12:14 PDT 2006



ST-RH036878

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Arizona 35.15 N 114.17 W 2739 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 3
G.M. Bonnin, D. Todd, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2003

Extracted: Tue May 23 2006

Confidence Limits | Seasonality | Location Maps | Other Info | GIS data | Maps | Help | Docs | U.S. Map

Precipitation Frequency Estimates (inches)

AEP* (1-in-Y)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
2	0.21	0.31	0.39	0.52	0.65	0.74	0.80	0.94	1.09	1.36	1.57	1.72	1.97	2.13	2.60	3.08	3.58	4.04
5	0.32	0.49	0.60	0.81	1.00	1.14	1.21	1.40	1.63	2.03	2.33	2.53	2.89	3.15	3.86	4.59	5.38	6.10
10	0.39	0.60	0.74	1.00	1.24	1.42	1.51	1.74	2.02	2.50	2.86	3.09	3.51	3.86	4.72	5.60	6.59	7.48
25	0.49	0.75	0.92	1.24	1.54	1.80	1.93	2.20	2.54	3.14	3.58	3.82	4.33	4.79	5.83	6.87	8.12	9.23
50	0.56	0.86	1.06	1.43	1.77	2.10	2.28	2.58	2.95	3.64	4.14	4.39	4.96	5.51	6.68	7.82	9.27	10.53
100	0.64	0.97	1.20	1.62	2.00	2.42	2.65	2.98	3.39	4.17	4.73	4.98	5.59	6.24	7.54	8.76	10.42	11.84
200	0.71	1.08	1.34	1.81	2.24	2.75	3.04	3.41	3.86	4.73	5.34	5.59	6.25	7.00	8.41	9.71	11.57	13.15
500	0.81	1.24	1.54	2.07	2.56	3.22	3.63	4.05	4.51	5.52	6.20	6.44	7.15	8.07	9.59	10.95	13.11	14.90
1000	0.90	1.37	1.70	2.28	2.83	3.60	4.12	4.57	5.06	6.15	6.89	7.11	7.87	8.92	10.50	11.90	14.28	16.23

Text version of table

* These precipitation frequency estimates are based on an annual maxima series. AEP is the Annual Exceedance Probability. Please refer to the documentation for more information. NOTE: Formatting forces estimates near zero to appear as zero.

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Accumulated 6-Hour Precipitation Depths

Total 100-year Depth (in): 2.98
Total 10-year Depth (in): 1.74

ref: Drainage Design Manual
for Maricopa County, Section 2.4.2

Total Watershed Area (mi^2): 0.339
Watershed Pattern Number: 1

Time	Accummated Depth (in)		6-Hour Distribution Patterns - Percent of Rainfall					Pattern for Watershed
	100-yr, 6-hr	10-yr, 6-hr	Pattern 1	Pattern 2	Pattern 3	Pattern 4	Pattern 5	Pattern 1
01Jan3000, 01:05	0	0	0	0	0	0	0	0.0
01Jan3000, 01:20	0.02	0.01	0.8	0.9	1.5	2.1	2.4	0.8
01Jan3000, 01:35	0.05	0.03	1.6	1.6	2	3.5	4.3	1.6
01Jan3000, 01:50	0.07	0.04	2.5	2.5	3	5.1	5.9	2.5
01Jan3000, 02:05	0.10	0.06	3.3	3.4	4.8	7.1	7.8	3.3
01Jan3000, 02:20	0.12	0.07	4.1	4.2	6.3	8.7	9.8	4.1
01Jan3000, 02:35	0.15	0.09	5	5.1	7.6	10.5	11.9	5.0
01Jan3000, 02:50	0.17	0.10	5.8	5.9	9	12.5	14.1	5.8
01Jan3000, 03:05	0.20	0.11	6.6	6.7	10.5	14.3	16.2	6.6
01Jan3000, 03:20	0.22	0.13	7.4	7.6	11.9	16	18.6	7.4
01Jan3000, 03:35	0.26	0.15	8.7	8.7	13.5	17.9	21.2	8.7
01Jan3000, 03:50	0.30	0.17	9.9	10	15.2	20.1	23.9	9.9
01Jan3000, 04:05	0.35	0.21	11.8	12	17.5	23.2	27.1	11.8
01Jan3000, 04:20	0.41	0.24	13.8	16.3	22.2	28.1	32.1	13.8
01Jan3000, 04:35	0.64	0.38	21.6	25.2	30.4	36.4	40.8	21.6
01Jan3000, 04:50	1.12	0.66	37.7	45.1	47.2	50	51.5	37.7
01Jan3000, 05:05	2.49	1.45	83.4	69.4	67	65.8	62.7	83.4
01Jan3000, 05:20	2.71	1.59	91.1	83.7	79.6	77.3	73.5	91.1
01Jan3000, 05:35	2.77	1.62	93.1	90	86.8	84.1	81.4	93.1
01Jan3000, 05:50	2.83	1.65	95	93.8	91.2	88.8	86.4	95.0
01Jan3000, 06:05	2.87	1.67	96.2	95	94.6	92.7	90.7	96.2
01Jan3000, 06:20	2.90	1.69	97.2	96.3	96	94.5	93	97.2
01Jan3000, 06:35	2.93	1.71	98.3	97.5	97.3	96.4	95.4	98.3
01Jan3000, 06:50	2.95	1.72	99.1	98.8	98.7	98.2	97.7	99.1
01Jan3000, 07:05	2.98	1.74	100	100	100	100	100	100.0

note: pattern 1 used for watersheds with areas less than 0.5 mi^2

ST-RH036880

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Project: Section 3

Job No.: 18449
Date: 5/24/2006
Calculated by: arv

Modified STANDARD FORM 4 from the Clark County Regional Flood Control District's Hydrologic Criteria and Drainage Design Manual

Stanley Consultants INC.
5820 S. Eastern Ave. Suite 200
Las Vegas, Nevada 89119
702.369.9396

Sub-Basin Data			Initial/Overland Time (Ti)			Travel Time (Tt)					Tc Check (Urbanized Basins)		Final Tc	TLAG	HEC-INPUT		Remarks
Designation	K (Default by CN)	Area (Acres)	Length (feet)	Slope (%)	Ti (Min)	Length (feet)	Slope (%)	V1 (FPS) (Manning)	V2 (FPS) (Manning)	Tt (Min)	Total Length (feet)	Tc= (L/180)+10 (Min)	Tc = Ti +Tt (Min)	(Tc*0.6)	Composite	Drainage Area (Sq. Mi.)	Tc>=10 for Non Urban
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(Min)	CN		Tc>=5 for Urban
S3-1	0.89	4.74	100	1.50	3.30	1530	1.50	2.47	3.75	7.95	1630	19.1	11.2	6.7	97	0.0074	
S3-2	0.89	6.65	150	0.60	5.41	2033	2.00	2.86	4.33	8.82	2183	22.1	14.2	8.5	97.2	0.0104	
P3-45	0.58	1.63	100	1.00	9.36	492	1.12	2.14	3.24	3.84	592	13.3	13.2	7.9	73.5	0.0025	
OS-3	0.63	17.65	300	1.00	14.77	2028	1.30	1.69	3.35	12.54	2328		27.3	16.4	77	0.0276	
OS-4	0.63	71.39	300	1.30	13.53	6615	1.30	1.69	3.35	35.34	6915		48.9	29.3	77	0.1115	

K = 0.0132*Cn-0.39 Ti = 1.8*(1.1-K)*L^(1/2)/(S^(1/3)) Generalized Manning's Equations

Existing Conditions	Developed Conditions
V1 = 14.8*(S/100)^0.5	V1 = 20.2*(S/100)^0.5
V2 = 29.4*(S/100)^0.5	V2 = 30.6*(S/100)^0.5

ST-RH036881

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Project: Section 3

Job No.: 18449
Date: 5/24/2006
Calculated by: arv

Stanley Consultants INC.

5820 S. Eastern Ave. Suite 200
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702.369.9396

Sub-Basin Data			Percent of Drainage Area within Cover Type and Hydrologic Condition (Sum Must=100%)					Curve Number for Cover Type and Hydrologic Condition				Hydrologic Soil Group Within Basin	Basin Composite Curve Number
Drainage Basin Name	Drainage Area (Acres)	Drainage Area (Sq. Mi.)	1	2	3	4	SUM	1	2	3	4		CN
S3-1	4.74	0.0074	50	50	0	0	100	98	96	77	73.5	B	97
S3-2	6.65	0.0104	60	40	0	0	100	98	96	77	73.5	B	97.2
P3-45	1.63	0.0025	0	0	0	100	100	98	96	77	73.5	B	73.5
OS-3	17.65	0.0276	0	0	100	0	100	98	96	77	73.5	B	77
OS-4	71.39	0.1115	0	0	100	0	100	98	96	77	73.5	B	77

Cover Type and Hydrologic Conditon							
ID	Description	Curve Numbers for Hydrologic Soil Group				Tbl. 602 Paragraph No.
		A	B	C	D	
1	Paved: curbs and storm sewers (excluding right of way)	98.00	98.00	98.00	98.00	1.04
2	Artificial desert landscaping	96.00	96.00	96.00	96.00	1.10
3	Desert shrub-major plants include saltbrush, greasewood.... -poor	63.00	77.00	85.00	88.00	4.13
4	12,000 sq. ft. lots	59.00	73.50	82.00	86.50	4.17, 4.18

APPENDIX B

STREET NORMAL DEPTH CALCULATIONS

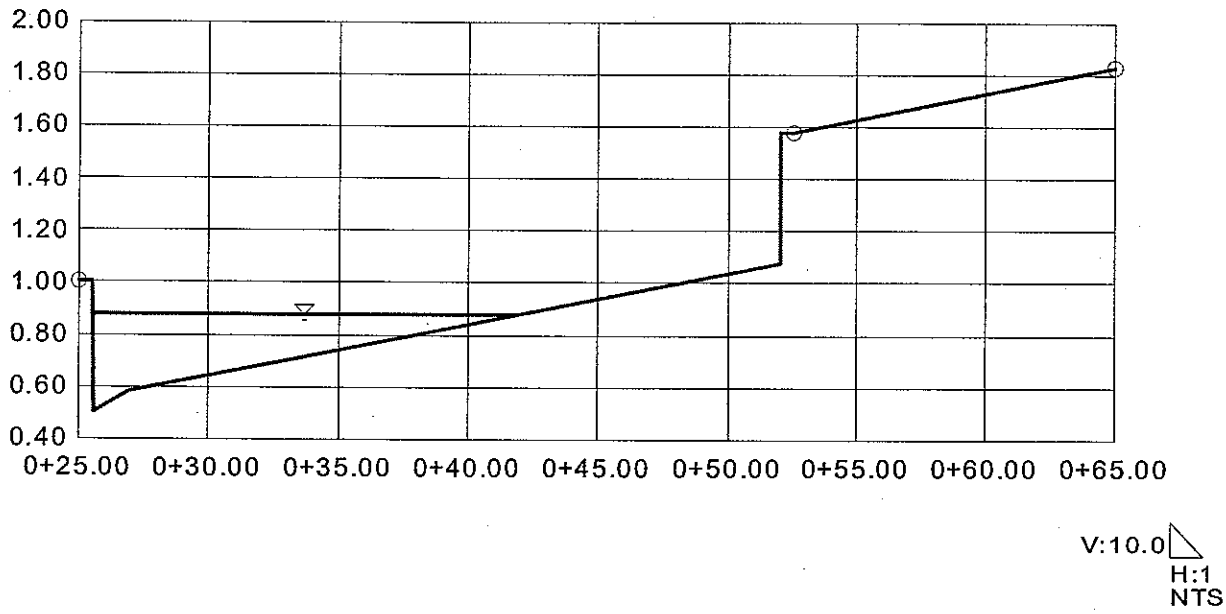
- EAST LOOP ROAD STA. 175+00
- EAST LOOP ROAD STA. 191+00

East Loop Road Sta. 175+00 - South Half - Roadway - Q10 = 8.5cfs

Cross Section for Irregular Channel

Project Description	
Worksheet	East Loop Road - South Half - Roac
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficier	0.016	
Channel Slope	0.013000	ft/ft
Water Surface Elev.	0.88	ft
Elevation Range	.50 to 1.83	
Discharge	8.50	cfs



East Loop Road Sta. 175+00 - South Half - Roadway - Q10 = 8.5cfs

Worksheet for Irregular Channel

Project Description	
Worksheet	East Loop Road - South Half - Roac
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Channel Sl	013000	ft/ft
Discharge	8.50	cfs

Options	
Current Roughness Meth	ved Lotter's Method
Open Channel Weighting	ved Lotter's Method
Closed Channel Weightin	Horton's Method

Results		
Mannings Coefficie	0.016	
Water Surface Elev	0.88	ft
Elevation Range	).50 to 1.83	
Flow Area	2.7	ft²
Wetted Perimeter	16.68	ft
Top Width	16.35	ft
Actual Depth	0.38	ft
Critical Elevation	0.92	ft
Critical Slope	0.006695	ft/ft
Velocity	3.15	ft/s
Velocity Head	0.15	ft
Specific Energy	1.03	ft
Froude Number	1.36	
Flow Type	Supercritical	

Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+25.00	0+52.50	0.016
0+52.50	0+65.00	0.035

Natural Channel Points	
Station (ft)	Elevation (ft)
0+25.00	1.00
0+25.50	1.00
0+25.58	0.50
0+27.00	0.58
0+52.00	1.08
0+52.00	1.58
0+52.50	1.58
0+65.00	1.83

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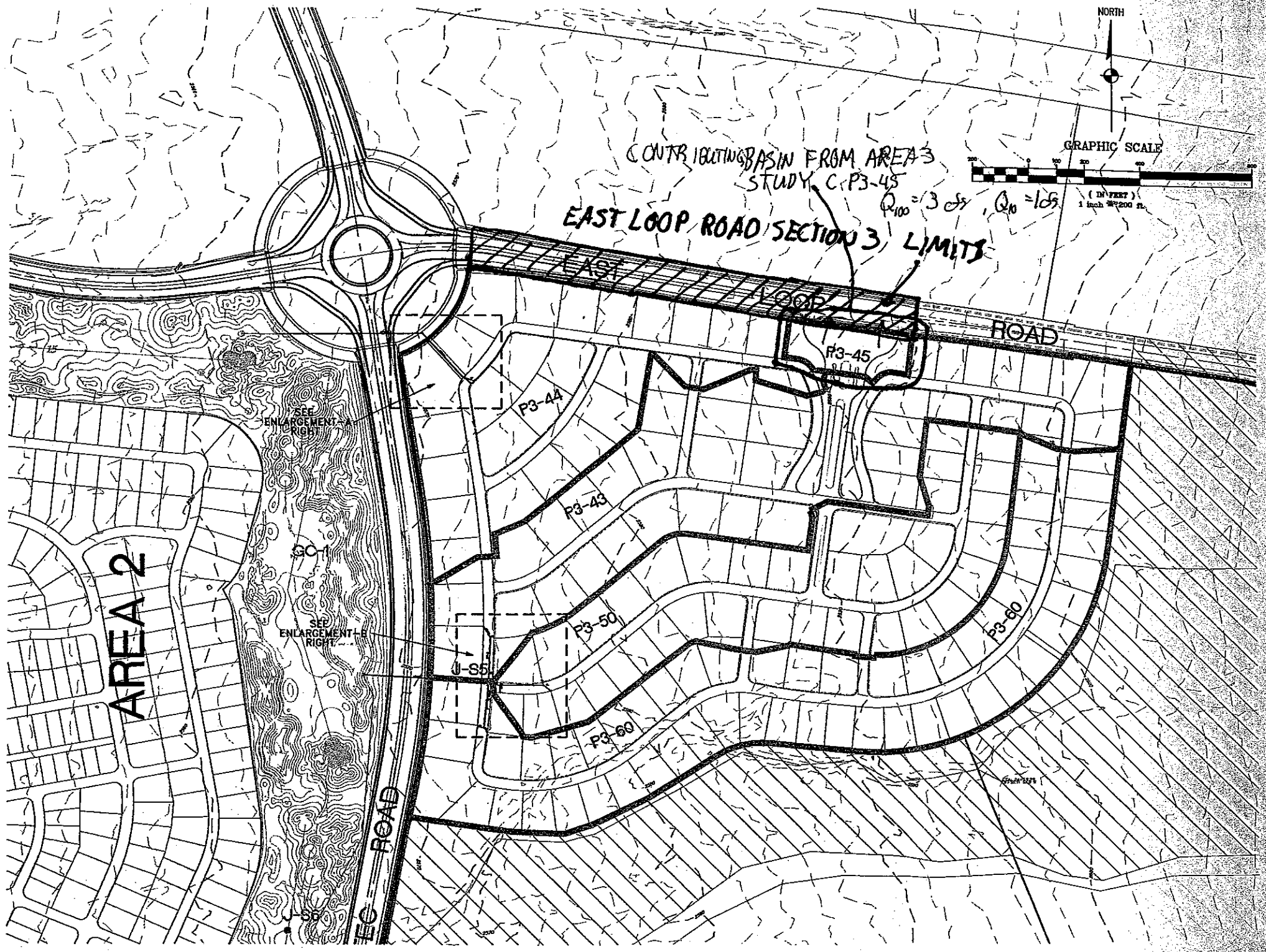
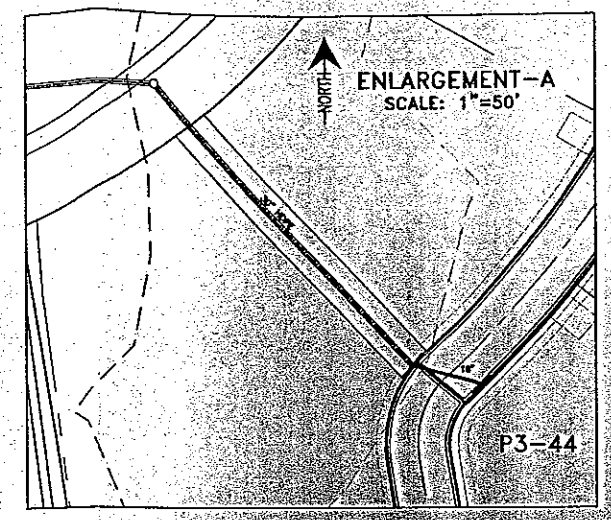
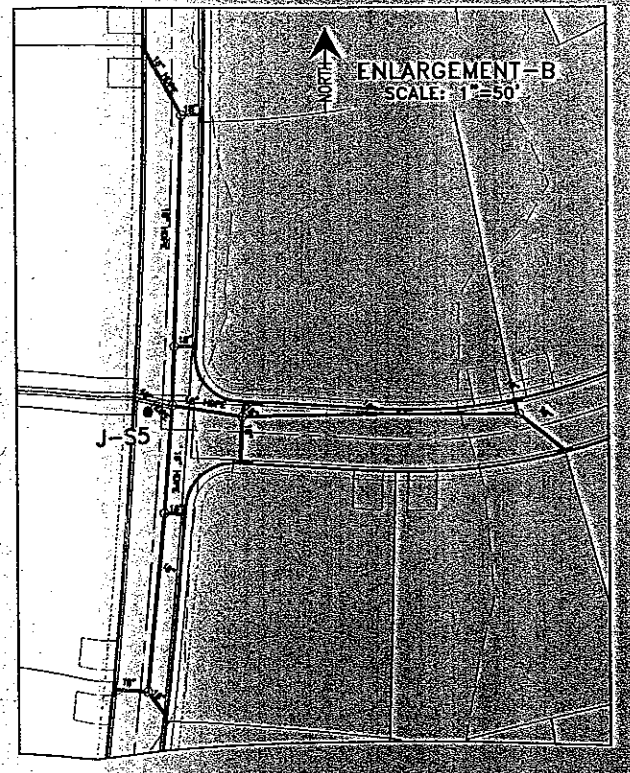
ST-RH036885



LEGENDS:

- SHED BOUNDARY
- SUB-SHED BOUNDARY (P1-99)
- JUNCTION POINT (J-C9)
- PROPOSED CHANNEL
- PROPOSED PIPE
- STORM DRAIN PIPE
- STORM DRAIN INLET





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GOLDEN VALLEY RANCH
AREA 3 DRAINAGE SUB-SHEDS
TECHNICAL DRAINAGE STUDY EXHIBIT

MOHAVE COUNTY ARIZONA FIGURE 3

ST-RH036886

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Project:

6-Hour Design Storm Distribution

Stanley Consultants INC.
5820 S. Eastern Ave. Suite 200
Las Vegas, Nevada 89119
702.369.9396

Project: 0

Job No.: 0
Date: 0
Calculated by: 0

Modified STANDARD FORM 4 from the Clark County Regional Flood Control District's Hydrologic Criteria and Drainage Design Manual

Stanley Consultants INC.
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Drainage Basin Name	Drainage Area (Acres)	Drainage Area (Sq. Mi.)	SCS Curve Numbers: Curve Numbers: Tbl. 602 Para-graph No.	Cover Type and Hydrologic Condition	Curve # for Hydrologic Soils Group A	B	C	D	Composite CN	Sub-Basin Data: Designation (1)	K (Default by CN) (2)	Area (Acres) (3)	Initial/Overland Time (Ti): Length (feet) (4)	Slope (%) (5)	Ti (Min) (6)	Travel Time (Tt): Length (feet) (7)	Slope (%) (8)	V1 (FPS) (Manning) (9)	V2 (FPS) (Manning) (10)	Tt (Min) (11)	Tc Check (Urbanized Basins): Total Length (feet) (12)	Tc= (L/180)+10 (Min) (13)	Final Tc: Tc = Ti +Tt (Min) (14)	TLAG: (Tc*0.6) (Min)	HEC-INPUT: Composite CN	HEC-INPUT: Drainage Area (Sq. Mi.)	Remarks: Tc>=10 for Non Urban, Tc>=5 for Urban
EXISTING CONDITIONS										EXISTING CONDITIONS																	
P3-43	25.15	0.0393		12,000 +/- resudebtuak kits	59	73.5	82	86.5	82	P3-43	0.65	25.15	174	1.00	10.68	1740	0.94	1.96	2.97	11.22	1914	20.6	20.8	12.4	82	0.0393	
P3-44	16.01	0.0261		12,000 +/- resudebtuak kits	59	73.5	82	86.5	82	P3-44	0.65	16.01	144	1.00	9.72	3112	1.08	2.10	3.18	17.66	3256	28.1	27.4	16.4	82	0.0261	
P3-45	1.63	0.0025		12,000 +/- resudebtuak kits	59	73.5	82	86.5	82	P3-45	0.65	1.63	100	1.00	8.10	492	1.12	2.14	3.24	3.84	592	13.3	11.9	7.2	82	0.0025	
P3-50	19.39	0.0303		7,000-8,000 resudebtuak kits	78	85.5	89.5	91.5	89.5	P3-50	0.78	19.39	261	1.00	9.31	2429	1.05	2.07	3.14	14.28	2690	24.9	23.6	14.2	90	0.0303	
P3-60	25.36	0.0396		7,000-8,000 resudebtuak kits	78	85.5	89.5	91.5	89.5	P3-60	0.76	25.36	274	1.00	9.53	3201	0.91	1.93	2.92	19.75	3475	29.3	29.3	17.6	90	0.0396	
				URBAN AREAS							K = 0.0132*Cn-0.39		Tt = 1.8*(1.1-K)*L^(1/2)/(S^(1/3))			Generalized Manning's Equations											
Notes:				1.01 Open space - poor	68	79	86	89								Existing Conditions											
				1.02 Open space - fair	49	69	79	84								V1 = 14.8*(S/100)^0.5											
				1.03 Open space/parks - good	39	61	74	80								V2 = 29.4*(S/100)^0.5											
				1.04 Paved (excludes right-of-way)	98	98	98	98																			
				1.05 Paved: curbs and storm drains	98	98	98	98																			
				1.06 Paved: open ditches (includes R/W)	83	89	92	93																			
				1.07 Gravel (includes R/W)	76	85	89	91																			
				1.08 Dirt: (includes R/W)	72	82	87	89																			
				1.11 Commercial & Business	89	92	94	95																			
				1.12 Industrial	81	88	91	93																			
				1.13 Apartments/Condos	81	88	91	93																			
				1.14 Townhouses/<= 6000 sq. ft.	80	87	90	92																			
				1.15 7000 sq. ft. lots	76	84	89	91																			
				1.16 8000 sq. ft. lots	73	82	88	90																			
				1.17 10,000 sq. ft. lots	61	75	83	87																			
				1.18 14,000 sq. ft. lots	57	72	81	86																			
				1.19 20,000 sq. ft. lots	54	70	80	85																			
				1.20 40,000 sq. ft. lots	51	68	79	84																			
				1.21 80,000 sq. ft. lots	46	65	77	82																			

different curve number used – P3-45 lies within "B" type soils
CN = 73.5

STANDARD FORM 4 FROM AREA 3 STUDY

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ST-RH036887

Typical both sheets

Water Surface Elevation W.S.E,

South Gutter Flowline + (flow depth from East Loop Road Sta. 191+00 - South Half - Q100 = 29.8 cfs w/ S = 1.3% (yeilds max depth) - 0.5')

example @ ~~[illegible]~~ 179+50: ~~591.51 + (0.83' - 0.5') = 91.84~~ 85.63 + (0.83 - 0.5') = 85.96

*(Sta. 175+00)

Area 3 Finished Floor Flood Protection Verification (FF - WSE ≥ 1.0ft)

1" = 50'

N

Sheet 1 of 2

Section 2

EAST LOOP RD. CL STATION 177+29.93

AREA 3 ENTRY C.L STATION 10+00.00

EAST LOOP ROAD (PUBLIC)

N82°04'W 1622.24'

PT = 180+88.06

PC = 180+02

SSMH # ELR-4

SSMH # ELR-5

15" PVC S.S.

24" D.I.P. W

1.30%

80' R.O.W.

25' C.E.

C.E. A

C.E. B

AREA 3

AREA 3

WSE = 82.40

WSE = 84.19

WSE = 85.96

W.S.E = ~~91.84~~ 91.97

1 PAD=88.9 FF = 89.9

2 PAD=86.7 FF = 87.7

55 PAD=95.7 FF = 96.7

Area 3 Finished Floor Flood Protection Verification (FF-WSE > 1.0 ft)

1" = 50'

N

Sheet 2 of 2

Section 3

EAST LOOP ROAD (PUBLIC)

SSMH # ELR-2

SSMH # ELR-3

24" D.I.P. W 2.30%

15" PVC S.S.

24" D.I.P. W 1.30%

15" PVC S.S.

N80°05'W 903.26'

WSE = 71.41

WSE < 75.28 (= 76 - 42(0.013) - 0.5 + 0.33)

WSE = 77.25

WSE = 79.06

WSE = 80.65

8 PAD=75.2 FF = 76.2

7 PAD=76.3 FF = 77.3

6 PAD=78.4 FF = 79.4

5 PAD=80.5 FF = 81.5

4 PAD=82.6 FF = 83.6

3 PAD=84.6 FF = 85.6

AREA 3

AREA 3

2572 2574 2576 2578 2580 2582

ST-RH036888

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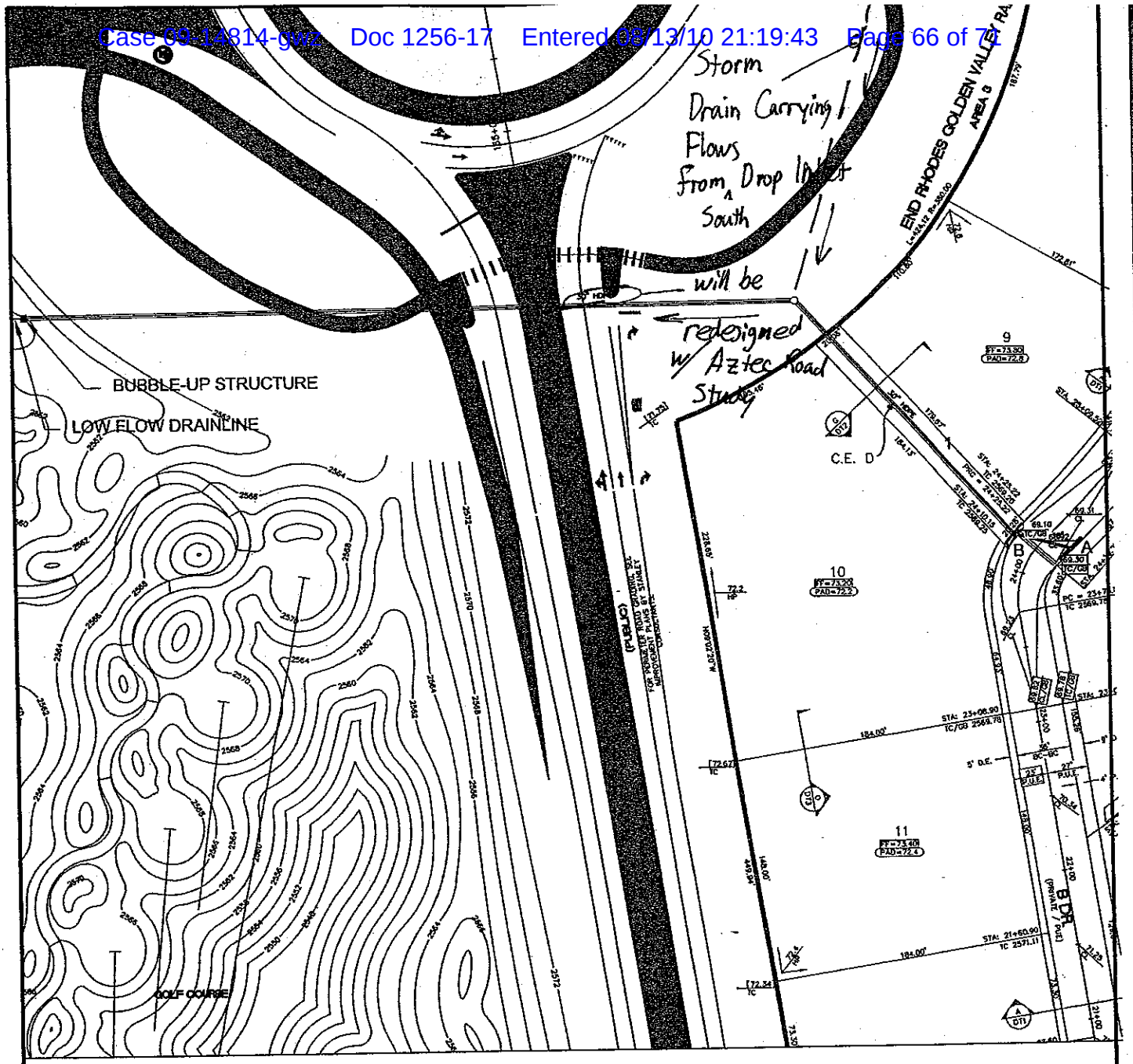

STORM DRAIN SYSTEM					
INLET	SIZE	Qinlet	Qintercept	Qbypass	Grade/Sump
A	14.5	19	11	8	G
B	17.5	27	15	12	S

SD PIPES		
PIPE	Qpipe	Size
1	26	30

BUBBLE-UP STR	
PIPE Type	Open Area
30 Type F	2.5 x 3.5

REVISIONS	DWN	APVD	APVD	DATE

Stanley Consultants INC.

DESIGNED RJM
DRAWN RJM
CHECKED
APPROVED
APPROVED
DATE 3/02/06

RHODES HOMES ARIZONA
GOLDEN VALLEY RANCH
AREA 3 – PHASE A

COMMON EASEMENT D
SHED P3-44

SCALE 1" = 100'

NO. A

REV. 0

FILENAME
CADD A1-R3
© STANLEY CONSULTANTS

RUNOFF CURVE NUMBERS
(URBAN AREAS[1])

Cover description		Curve numbers for hydrologic soil group—			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved: curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
See Table 602A					
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94

1 Average runoff condition, and $I_a = 0.2S$.

2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system. Impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using Figure 603.

3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

4 Composite CN's for natural desert landscaping should be computed using Figure 603 based on the impervious area percentage (CN #98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using Figure 603 based on the degree of development impervious area percentage) and the CN's for the newly graded pervious areas.

Revision	Date

RUNOFF CURVE NUMBERS
(SEMIARID RANGELANDS[1])

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition[2]	A[3]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

[1]Average runoff condition, and $I_a = 0.2S$.

[2]*Poor:* <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: >70% ground cover.

[3]Curve numbers for group A have been developed only for desert shrub.

Revision	Date

WRC ENGINEERING

REFERENCE: SCS TR-55, USDA, June 1986.

TABLE 602
4 of 4

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

RUNOFF CURVE NUMBERS - RESIDENTIAL DISTRICTS

Average Lot Size or Usage[1]	Percent Impervious[2]	Curve Number for Hydrologic Soil Groups			
		A	B	C	D
Apartments/Condos	72	81	88	91	93
Townhouses/6,000 sq ft lots or less[3]	69	80	87	90	92
7,000 sq ft lots	63	76	84	89	91
8,000 sq ft lots	58	73	82	88	90
10,000 sq ft lots	38	61	75	83	87
12,000 sq ft lots	35	59	73.5	82	86.5
14,000 sq ft lots	30	57	72	81	86
20,000 sq ft lots	25	54	70	80	85
40,000 sq ft lots	20	51	68	79	84
80,000 sq ft lots	12	46	65	77	82

1 Lot size should represent the size of the average lot and not the gross acreage divided by the number of lots.

2 Actual percent impervious value should be compared to selected land use type.

3 In cases where average residential lots are smaller than 6,000 sq ft, commercial/business/industrial land use should be used.

Revision	Date

REFERENCE:

TABLE 602A

RUNOFF CURVE NUMBERS
(URBAN AREAS[1])

Cover description		Curve numbers for hydrologic soil group—			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved: curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved: open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					

See Table 602A

Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94

1 Average runoff condition, and $I_a = 0.2S$.

2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system. Impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using Figure 603.

3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

4 Composite CN's for natural desert landscaping should be computed using Figure 603 based on the impervious area percentage (CN #98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using Figure 603 based on the degree of development impervious area percentage) and the CN's for the newly graded pervious areas.

Revision	Date

APPENDIX D

PLANS – NOT INCLUDED WITH THIS STUDY